THE USE OF AN IPAD APP TO DELIVER A TIME-DELAY TAPED-WORDS INTERVENTION TO STUDENTS AT-RISK FOR READING DIFFICULTIES

by

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ABSTRACT

The purpose of the current study was to empirically evaluate the effectiveness of a specifically designed iPad app to administer the time-delay taped-words intervention. This study is an extension of previous research that has shown the time-delay taped-words intervention to be effective at improving reading fluency. Results of the current study include an increase in word reading as well as generalized increases in oral reading fluency for all participants. Additionally, results from the acceptability survey indicated that the intervention app was well received by both teachers and students. Implications for future research using mobile devices to administer interventions are discussed.

It is with unending gratefulness and love that I dedicate this dissertation to my husband, James Pummel, and parents, Roy and Kathleen Lindsay. Their grace, encouragement, and continued support made this venture a reality. It is with high regard and gratitude that I extend thanks to Joseph Andolina, who shared his talents and brought this app to life. A special thanks to the school psychology faculty who helped nurture the professional that I have become and for always encouraging me along the way.

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INTRODUCTION

Reading, writing, and arithmetic are widely accepted as the core components of education. The acquisition of skills in these areas is essential for students to be active participants in their education as well as to gain and express knowledge in other academic areas. These foundational skills are vital within the classroom and beyond and necessary to promote lifelong learning.

Reading skills become ever more critical as the student is required to read material across all content areas and to gain information. The timeframe for acquiring basic yet effective reading skills is short and critical to long-term success. According to the 2007 National Assessment of Educational Progress, 33% of fourth graders have not achieved basic levels of reading. Therefore, one can assume that this one-third of fourth graders who have not achieved basic levels of reading will also struggle to acquire essential information in other academic areas as well. Failing to develop competency as a reader puts a person's ability to become an independent lifelong learner in jeopardy. These surprising statistics further warrant the need for all students to become competent and skilled readers.

Common Core Standards

Most states have now adopted the Common Core State Standards (CCSS) in English Language Arts and Mathematics. The Common Core State Standards have

been identified in order to provide a guideline for states, teachers, and parents in order to assure that all students are provided with a high-quality education. The CCSS "provide a consistent, clear understanding of what students are expected to learn." "The standards are designed to be robust and relevant to the real world, reflecting the knowledge and skills that our young people need for success in college and careers" (National Governors Association for Best Practices, Council of Chief State School Officers, 2010). The standards create the foundation to identify what all students should learn and know at each grade level. The standards are not a curriculum for teachers to adopt, but a framework that teachers may use to align their curriculum, teaching strategies, and experiences. With consistent guidelines across states for student achievement, teachers still maintain the freedom to individualize instruction and implement interventions to assure that all students meet these goals.

Reading

Reading is an essential skill that students must acquire in order to be successful in school and beyond. The National Center for Educational Statistics (2009) reported that 30 million adults have below-basic levels of English literacy and 63 million read at a basic level. Thus, 44% of adults in America could benefit from English literacy instruction. Learning to read is challenging and multidimensional. The National Institute for Literacy (2009) has identified five key components of reading that include: phonemic awareness, phonics, fluency, vocabulary, and comprehension.

Phonemic awareness involves teaching children how to manipulate phonemes in spoken syllables and words. Research has shown that phonemic awareness and letter knowledge are the two best predictors of how well children will learn to read during their first two years of instruction (National Reading Panel, 2006). Phonics, or the alphabetic principle, is the ability to associate sounds with letters and use the sounds to form words (Shapiro, 2004). Subskills of the alphabetic principle include decoding, sight word recognition, sounding out words, word analysis and recognizing word patterns (The University of Texas Center for Reading and Language Arts, 2004).

Beginning readers rely on letter-by-letter decoding, associating a letter with a specific sound and blending that sound with the sound of the next letter(s) to form a word. Repeated association with a word's pronunciation and visual representation will lead the reader to process letter clusters and entire words as units. As this process becomes more rapid, repeated exposure to the word allows the reader to store words as whole spelling units that can be accurately and automatically recognized as "sight words." Proficient reading requires decoding, the process leading to word recognition, fluency, and comprehension. Fluency is the ability to read quickly and accurately (Rathvon, 2008). Comprehension is the ability to derive meaning from text through the process of the reader making connections between their prior knowledge and the text they are reading (Rathvon, 2008; McLaughlin, 2012).

Montana's common core standards for Reading, Foundational Skills, indicate that by the end of grade four students should be able to use combined knowledge of

all letter-sound correspondences, syllabication patterns, and morphology to accurately read unfamiliar multisyllabic words in context and out of context (Montana Common Core Standards and Assessments, 2011). In other words, the nuts of bolts of reading phonics and word recognition should be mastered by the end of fourth grade in order to allow readers to accurately decode unknown words and use context to derive meaning.

Reading fluency is the combination of accuracy and rate of reading. Both of these aspects of reading must be considered in order to determine a reader's skill level. Rate alone can only assess how quickly a student reads a passage, but does not assess how many words the reader has read correctly. Conversely, a student may read accurately but at a slow rate (Hasbrouck & Tindal, 1992). Fluency requires automaticity, which is the ability to associate letters with sounds and to recognize sight words and spelling patterns. Half of all written words in the English language are composed of just 100 sight words and their variants (Fry, 1980). Therefore, the ability to accurately and quickly recognize these frequently used words is an important skill for early readers to master.

Pikulski and Chard (2005) view fluency as an essential part of the developmental process of building decoding skills in order to develop a causal and reciprocal relationship with comprehension. The rapid reading of high-frequency and decodable words is critical for reading comprehension (Chard, Ketterlin-Geller, Baker, Doabler, & Apichatabutra, 2009; Rasinski, 2000; Shapiro, 2004; The University of Texas Center for Reading and Language Arts, 2004). If a students' attention is fully captivated by decoding words, they demonstrate little to no

attention capacity for comprehension. Furthermore, current research suggests an important developmental shift in the impact of text reading fluency on reading comprehension in the repeated reading. Kim & Wagner (2015) found that text reading fluency begins to significantly impact reading comprehension starting in the repeated reading.

The demand on comprehension grows each year because students are responsible to comprehend more and more informational texts throughout their schooling. The National Assessment of Educational Progress (2009) requires an increasing proportion of informational to literary text on its assessments as students progress throughout the grades. For example, fourth-grade assessments are comprised of 50% informational and 50% literary texts, eighth-grade assessments are comprised of 55% informational texts, and 12th-grade assessments are comprised of 70% informational texts (National Assessment Governing Board, 2008). Thus, if fluency is not adequately established, students may struggle to effortlessly read through material, glossing over the less informational structural components of text, in order to understand the overall purpose of texts and gather the important details.

Teachers can easily identify fluent and dysfluent readers by listening to them read aloud. Fluent readers use inflection and variations in pitch and tone, and also read through text efficiently, with few errors. In contrast, dysfluent readers may read with a monotone voice. Most importantly, dysfluent readers read cautiously slowly which can significantly interfere with their ability to comprehend the text and their motivation to read (Thoermer & Williams, 2012). Motivation is a key

factor in comprehension (McLaughlin, 2012). The abilities to read and understand new words are vital components to reading comprehension. If a student struggles to read basic sight words, reading will be belabored and difficult and the student may become discouraged and disinterested in reading.

Edyburn (2006) argues that when students are unable to experience success in a learning activity, they have not failed to learn. Instead they have learned that they don't like the subject matter and internalize the failure in a way that reflects an attitude that they aren't good at the subject. Edyburn suggests this attribution is so powerful that it has the ability to transgress across generations, which further closes the door to learning and opportunities. Edyburn states: "Rather than addressing the issues of poor performance, educators often search for reasons to explain poor performance, become sidetracked, and fail to intervene with appropriate supports" (p. 21). Likewise, Slavin, et al. (1991) stated: "Once a child is academically handicapped (or significantly behind his or her peers for any reason), neither mainstreaming nor special or remedial education is likely to bring the child up to age appropriate achievement norms" (p. 373). They proposed that the key focus of education should emphasize prevention, and early, intensive, and continued intervention to keep student achievement within normal limits.

Response to Intervention

Response to intervention (RTI) is the proactive approach of identification and service delivery designed to target students with behavioral or academic difficulties as soon as they begin to struggle. The focus of RTI is to deliver services

that are matched to the needs of the student and to frequently monitor student progress in order to accurately determine the student's response to the intervention (Justice, 2006; Rathvon, 2008).

The traditional discrepancy model of reading disability identification relies on the existence of a significant discrepancy between a student's Intelligence Quotient (IQ) and their academic achievement as measured by standardized assessments. Critics of the traditional discrepancy model of reading disability identification argue that many children are misdiagnosed with a reading disability when in fact they would succeed given the appropriate opportunities (Justice, 2006). Deno (1986) suggested that placement in special education must be based on evidence of the student's improvement rather than the agreement of professionals alone. Researchers have long acknowledged that commercially developed standardized and norm-referenced tests of achievement are inadequate for making decisions regarding individual educational placement and programs (Deno, 1985). RTI, in contrast, provides a model of identification that is designed to differentiate between students who have experiential-based and cognitive-based reading difficulties (Justice, 2006). Buffum, Mattos, and Weber (2012) state that the purpose of RTI is to systematically provide every child with the time and support needed to learn at high levels.

Common components of RTI models include the use of increasingly intensive tiers of intervention, research-based instruction and intervention, a problem-solving approach for matching interventions with students' needs, and systematic data collection and monitoring to determine if students are making adequate

progress (Rathvon, 2008). Buffum et al. (2012) have identified four practices every RTI model should employ in order for all students to succeed. The authors refer to these practices as the four Cs: collective responsibility, concentrated instruction, convergent assessment, and certain access. Collective responsibility refers to the shared belief that all members of the association are responsible to ensure high levels of learning for every child. Concentrated instruction is a systematic process of identifying the knowledge and skills that students must master and determining the specific learning needs for each child. This is supported by convergent assessment, an ongoing process of collectively analyzing evidence to identify learning needs and evaluate the effectiveness of the instruction. Lastly, certain access is a systematic process that guarantees every student's learning needs are met. These guiding practices are essential in order for learning to be the constant and time and instruction are varied to meet the needs of all students. The needs of students are met through the varied time and instruction across three Tiers.

The Tier 1 level is synonymous with the general education classroom, which should employ an evidence-based curriculum that allows for adequate instructional time and opportunities for the students to practice. Screening for academic and behavioral problems and systematic progress-monitoring are conducted at the Tier 1 level for all students. Although the Tier 1 level employs a high-quality evidence-based reading curriculum, some students will fail to make adequate progress (Rathvon, 2008). Students' growth is tracked and analyzed through the use of progress-monitoring probes and data. Therefore, once a problem has been identified, the student can begin receiving intervention support at the Tier 2 level.

Academic support at the Tier 2 level can be administered in a small group setting or through individualized interventions (Rathvon, 2008). The goal of Tier 2 instruction is to accelerate the pace of the students' reading development so they may achieve grade-level competencies in reading by the end of the academic year (Justice, 2006). Progress-monitoring is conducted more frequently at the Tier 2 level to monitor student growth and guide educational decision-making. Students who fail to make adequate progress at the Tier 2 level are either qualified for special education or receive intensive individualized instruction at the Tier 3 level (Justice, 2006; Rathvon, 2008).

The reauthorization of the Individuals with Disabilities Education Improvement Act of 2004 (IDEA, 2004) permits local education agencies to use up to 15% of federal funds for early intervening services, especially for those targeted toward students in kindergarten through third grade who have not qualified for special education, but who require additional behavioral or academic support to succeed in a general education environment (Rathvon, 2008). This allocation of funds further supports the basis for providing intervention services at Tier 2 and Tier 3 levels for students who fail to make adequate progress within the general education curriculum but are not better served within special education.

Curriculum-Based Assessment

In order to determine a student's level of academic achievement within the RTI model, assessments are utilized at both the classroom- and individual-level. Burns and VanDerHeyden (2006) define RTI as "the systematic use of data-based

decision making to most efficiently allocate resources to enhance learning outcomes for all children" (p. 3). Benchmark measures are used to evaluate classroom performance in reading to inform instructional practices and set goals. Individual student progress in the RTI model is assessed through the use of progress-monitoring, commonly referred to as curriculum-based measurement (CBM) (Shapiro, 2004).

Curriculum-based measurement evaluates an individual student's performance on specific indicators of progress in reading. CBM is a set of standardized, fluency-based procedures designed to measure a student's progress towards intervention goals or grade-level standards. Measurement procedures are brief, can be administered frequently, and are based on the student's own instructional curriculum (Rathvon, 2008). CBM is conducted a minimum of three times per year or on a routine basis (Hasbrouck & Tindal, 2006). CBM measures must be sensitive to instructional change over time in order to evaluate student progress (Shapiro, 2004).

Curriculum-based measures were developed with a specific set of characteristics in mind. They must be reliable and valid, simple and efficient, easily understood and interpretable, and inexpensive. Reliability and validity research on CBM revealed, "a simple datum like the number of words read aloud correctly and incorrectly from a basal text reliably and validly discriminates growth in reading proficiency throughout the elementary school years" (Deno, 1985, p. 224). Therefore, it was posited that the number of words read correctly and incorrectly in one minute could be used to monitor growth in reading and as a measure of reading

achievement (Deno, 1985).

The characteristics of CBM allow for many advantages over standardized assessments. These advantages include increased communication among professionals, increased sensitivity of measures, an improved database of student growth, and peer referencing options. Individual student data can be represented on a graph to allow for the quick visual assessment of student performance by multiple professionals (Deno, 1985). Curriculum-based measurements have been shown to be effective in evaluating changes in student performance in educational programs. School psychologists and teachers can use CBM to test hypotheses regarding program modifications and to identify more effective treatments (Deno, 1986).

Curriculum-based measurements can be administered quickly and provide an estimate of the student's growth over time to predict whether goal attainment is likely to occur with the given intervention (Deno, 1986; Justice, 2006). The sensitivity of CBM measures allows educators to evaluate a student's growth over relatively short periods of time (e.g., days or weeks). In contrast, traditional standardized assessments are not sensitive enough to predict change within such restricted time periods. Due to the ease of administering CBM, school and district norms can be easily obtained in addition to norms of larger populations that have been collected through research (Deno, 1985).

There are two types of CBM for reading, oral reading fluency and maze fluency. Oral reading fluency focuses on two components of fluency: rate and accuracy (Hasbrouck & Tindal, 1992; Hasbrouck & Tindal, 2006). In maze fluency, the student is given a passage in which every seventh word has been deleted and

replaced with a choice of three words. The student reads the passage silently for a specified amount of time and circles one replacement word from each cluster of options. The correct number of replacements is scored (Rathvon, 2008).

In oral reading fluency, the student is given a passage of text, known as an oral reading probe, that is written at an end-of-year competency level. The student is allowed 1-minute and instructed to read the passage aloud. The number of words read correctly (words correct per minute, WCPM) is the score. Research has shown that oral reading fluency is a powerful indicator of overall reading competence. It is highly correlated with reading comprehension and is the best predictor of year-end reading achievement (Deno, 1985; Good, Kaminski, & Dill, 2002; Hasbrouck & Tindal, 2006; Rathvon, 2008; Schilling, Carlisle, Scott, & Zeng, 2007).

Components of Effective Academic Interventions

Burns, VanDerHeyden, and Boice (2008) identified five components of effective academic interventions. The intervention must first be correctly targeted towards the skill to be learned, create opportunities for the student to respond, as well as provide the student with immediate feedback. The intervention must use explicit instruction to teach the skill. Students should be taught within their instructional level to ensure the student is challenged and has the opportunity for success (Burns et al., 2008; Rasinski, 2000; Shapiro, 2004). Effective interventions in reading must concentrate on the acquisition of reading fluency, vocabulary building, and comprehension (Shapiro, 2004). Reading interventions are commonly targeted toward one subskill of reading yet still have potential to improve other

skills because of the interrelated nature of the reading process (Rathvon, 2008).

Creating opportunities to respond is an important intervention component. To achieve success in fluency, students must have repeated opportunities to practice while receiving corrective feedback (Nist & Joseph, 2008; Shapiro, 2004). In addition to creating opportunities to respond, teachers should also consider creating opportunities to respond through different modalities. McLaughlin (2012) noted that oral and written responses are the most commonly used modes of response for demonstrating comprehension. However, in addition to oral and written responses, teachers should consider offering multiple modes of response because it is motivating to all students but particularly beneficial for struggling readers. Furthermore, struggling readers may experience a combination of other challenges, such as attention, speech, or fine motor difficulties. Providing these students with multiple opportunities to respond through a modality that deemphasizes articulation and fine motor capabilities, and assists with monitoring attention to task is important for learners to experience success.

Feedback is also an important component of effective interventions to prevent students from learning incorrect information. Belfiore, Skinner, and Ferkis (1995) found that acquisition of sight words was increased when students with learning disabilities were presented with immediate corrective feedback over trials, rather than when students were instructed to consecutively repeat their response. Multiple studies examining feedback provided to students with Emotional and Behavioral Disorders (EBD) had positive effects on math and reading accuracy no matter if it was provided as written, corrective, or performance feedback (Vannest,

Harrison, Temple-Harvey, Ramsey, & Parker, 2010). Time-delay procedures have been found to minimize student errors because correct feedback is immediately provided, regardless of whether the student failed to respond, responded incorrectly, or responded correctly (Stevens & Schuster, 1999).

Students should be taught within their instructional level to ensure they are challenged and have opportunity for success (Burns et al., 2008; Rasinski, 2000; Shapiro, 2004). Pikulski and Chard (2005) suggested incorporating "practice in the recognition of high-frequency vocabulary words" (p. 513) as an essential component in an instructional program based on the concept of fluency. Research suggests that if a child correctly identifies a printed word as little as four times, they will be able to identify the word accurately without attending to the individual letters, sounds, or sound-associations (Reitsma, 1983).

Shorter and more frequent intervention sessions may be more effective and are preferable to students. Pikulski & Chard (2005) noted that practice sessions should be brief and occur within and across instructional days. Nist and Joseph (2008) found that students preferred reading tasks that consisted of all unknown words. They hypothesized that this preference may be because the unknown words took the shortest amount of time to complete compared to interventions that incorporated known words.

Research-Validated Interventions

One method of intervention that has been shown to increase reading fluency is a time-delay intervention such as the time-delay taped-words (TDTW)

intervention or variations: taped-words (TW), taped-problems (TP), or taped-numbers (TN). Time-delay interventions have commonly been used to teach academic skills (e.g., Casey, 2008; Freeman & McLaughlin, 1984; McCallum, Skinner, & Hutchins, 2004; Todd, 2010; Pummel, 2011; Krohn, Skinner, Fuller, & Greear, 2012) but have also been shown to be effective at teaching a variety of other life skills, such as purchasing items (e.g., McDonnell, 1987; Sandknop, Schuster, Wolery, & Cross, 1992), reading a recipe (Schuster & Griffen, 1991), and spontaneous speech (Ingenmey & Van Houten, 1991). It has also been used with a variety of individuals, including students with learning disabilities (e.g., Freeman & McLaughlin, 1984), mental retardation (e.g., Casey, 2008; McDonnell, 1987; Sandknop et al., 1992; Sterling, Robinson, & Skinner, 1997), emotional and behavioral disorders (e.g., Skinner & Johnson, 1995), autism (e.g., Ingenmey & VanHouten, 1991; Rogers, Hemmeter, & Wolery, 2010), English language learners (Bliss, Skinner, & Adams, 2006; Krohn, et al., 2012), and students in a general education classroom (e.g., McCallum, Skinner, Turner, & Saecker, 2006; Windingstad, Skinner, Rowland, Cardin, & Fearrington, 2009).

The TDTW intervention involves students listening to a recording of sight words or math problems followed by a corresponding answer. The answer is provided at constant, progressive, or varying time-delays. When a constant time-delay is used, the tape recording provides the answer at a fixed interval of time (e.g., 3 seconds) on all trials. A progressive time-delay uses increasing delays on subsequent trials. A varying time-delay typically starts with a no-delay or 1-second-delay trial, then increases by 2 or 3 seconds on subsequent trials and, finally

decreases to a 1- or 2-second time-delay on the last trial. The TDTW intervention typically utilizes a corresponding worksheet that students are instructed to use to record their answers. Students are either instructed to read along with the recording or to "beat the tape" by stating or writing the answer before they hear it on the recording (Freeman & McLaughlin, 1984; McCallum et al., 2004; McCallum, Schmitt, Schneider, Rezzetano, & Skinner, 2010).

Freeman and McLaughlin (1984) developed the TW intervention. They posited that the use of a tape recorder might expedite the acquisition of high-frequency sight words for high school students with learning disabilities. They hypothesized that it might also allow for independent correction of miscalled words in reading assignments and increased response rates. In addition, the TW intervention would allow the teacher to spend more time and energy on teaching strategies that required his/her physical presence. An audiotape with 80 words recorded per minute was used to implement the intervention. Students were instructed to read the words along with the tape recording. Students then went to a teacher station and read the list of words out loud to a teacher for a 1-minute sampling, which served as the dependent variable.

Results of this intervention showed that all six students had faster oral reading rates and lower error rates compared to baseline. This intervention modeled correct word pronunciations at a higher reading rate, which likely contributed to the improvements. The researchers suggested that this intervention may be also be effective at teaching vocabulary words, phonics instruction, or to teach reading in context. Moreover, the use of a reusable tape for modeling can be

much more time effective than one-on-one instruction to teach sight words (Freeman & McLaughlin, 1984).

Skinner and Johnson (1995) recognized that although research utilizing TW had provided evidence in support of the intervention, the variables that caused increases in reading performance had not been identified. In their study, students with behavioral and learning problems were exposed to a control condition and two TW conditions. Students completed each intervention condition daily followed by an assessment for each condition's word list that did not utilize a tape recording. In the assessment only (AO) control condition, students were given a list of 15 words and asked to read them aloud. The fast taped-words (FTW) condition included 15 words recorded at a rate of 1-second per word. The slow taped-words (STW) condition included 15 words recorded at a rate of 5 seconds per word. Students read both the FTW and STW words once along with the recording and then independently to assess reading rates. Results were collected for the number of words read correctly and number of words read correctly per minute.

The researchers found that both the FTW and STW conditions resulted in greater increases in accuracy and rate than the AO condition. Given these results, the authors reasoned that simply being provided with opportunities to respond or to practice reading words might not produce gains for students with very low reading skills, such as those in this study. The STW condition was more effective at decreasing reading errors for two of the three students. The other student showed no difference in error rates. Although not conclusive, this suggests that allowing more time between the presentations of words may be more effective for some

students. The authors concluded that proper modeling of reading is effective at increasing word list reading accuracy; however, more research is necessary to determine the reason for the discrepant results among students (Skinner & Johnson, 1995).

Sterling et al. (1997) used a TW intervention to teach sight words to students with mental retardation. Recorded words were presented with alternating treatment phases at either 1-second or 5-second intervals. Results showed that both the 1-second and 5-second intervals produced increases in the acquisition of sight words. Vannest et al. (2010) reviewed four studies that modified instructional time with students who had Emotional and Behavioral Disorders (EBD) and found that providing sufficient time-delays, providing an instructional pause prior to student response, or increasing the amount of teacher-directed instructional time resulted in an average increase in accuracy of 62% across interventions.

Bliss et al. (2006) extended the research of the effectiveness of the TDTW procedure. The researchers implemented the intervention using a multiple-baseline design across word lists to increase sight word recognition of a fifth-grade English language learner. In addition to the effectiveness of the intervention, the TDTW procedure is also appealing to teachers because students can be taught to self-administer the intervention. The researchers posed that future research should collect systematic treatment integrity data.

Neddenriep, Fritz, and Carrier (2011) employed a reading fluency intervention with fourth-grade students who were at-risk for not meeting yearly goals in reading comprehension and fluency. The intervention utilized the research-

validated principles to increase reading fluency, namely, repeated opportunities to practice while receiving corrective feedback (Nist & Joseph, 2008; Shapiro, 2004), which are also used in TDTW procedures. Results of their study indicated that all students made gains in fluency compared to baseline. They reported that 4 out of the 5 participants also made gains in reading comprehension at a rate that exceeded the expected growth rate for fourth-grade students.

McCallum et al. (2004) adapted the TW intervention to develop the TP intervention to address mathematics division fact fluency deficits. In addition to targeting math facts, the researchers also encouraged students to write the correct answer *before* it was provided by the tape and employed a progressive time-delay. Time-delays began at 1 second to decrease errors, increased by 5-second intervals to promote independence, and then decreased to encourage automaticity. Audio cues served as feedback to reinforce correct responses and correct inaccurate responses. The participant was a 10-year-old African American male. The student practiced a list of simple division problems five times per intervention session, each presented at a different time-delay. A multiple-probe-across-tasks design was used to evaluate the results. Researchers found this method to be successful in increasing the student's digits correct per minute while solving division problems. Thus, it was concluded that TP was effective at increasing a student's division fact fluency.

McCallum et al. (2006) and Windingstad et al. (2009) extended the research examining the utility of the TP intervention as a classwide intervention to increase mathematical fact fluency. The McCallum et al. study was conducted with a third-grade general education class. The material was presented using varying time-

delays and implemented classwide. The intervention utilized a multiple-baseline-across-tasks design and digits correct per minute (DCM) served as the dependent variable. The study was conducted for 3 weeks and almost doubled the class's average fluency for multiplication facts.

Windingstad et al. (2009) conducted a classwide TP intervention in a rural second-grade classroom to increase addition fact fluency. The intervention was administered using a varied time-delay. It provided the addition facts over four trials. The varied time-delays included a no-delay trial followed by two 2-second-delay trials and lastly a 1-second-delay trial. Following the presentation of the TP, students were administered a sprint sheet in which the students were given another opportunity to respond to the problems without the use of the recording. Students were then administered an assessment sheet that contained 15 or 16 problems, and they had 30 seconds to complete it. DCM served as the dependent variable to assess increases in fluency. Percent correct was also calculated to assess increases in accuracy. Although all students made gains in fluency, researchers found that intervention effectiveness varied across students. Fluency gains were maintained at follow-up. Percent correct data showed that the intervention had little impact on student accuracy, which may be explained by possible ceiling effects since the class had an average accuracy rate over 90% at baseline.

Researchers questioned whether TP intervention was necessary for this class given the high preintervention accuracy rates. Previous research has suggested that once accuracy is established, timed assessments are sufficient to increase fluency (as cited in Windingstad et al., 2009). Thus, more research is needed to determine

whether TP intervention is more appropriate to use with students who have not acquired accuracy with math facts. Researchers also stated the need to examine the use of TP intervention within RTI models of service delivery to prevent skill deficits (Windingstad et al., 2009). Results from both studies showed immediate and sustained increases in fact fluency and further validated the efficacy of TP intervention to increase academic skill fluency (McCallum et al., 2006; Windingstad et al., 2009).

McCallum et al. (2010) compared the effectiveness of the TP intervention on subtraction fact fluency with and without the addition of a group-rewards contingency. This intervention was conducted across two second-grade general education classrooms that included 20 African American students in each class of varying ability levels. At the start of the intervention, 39 of the 40 students were performing below grade level on subtraction fact fluency. A CD player and CDs were used to deliver the TP. This study utilized a 2-second time-delay for all problems, and each problem was presented twice in an intervention session. Both classrooms received the same assessments and TP procedures. A group reward contingency was used with only one classroom. This classroom was awarded a teacher-chosen reward if the mean score had increased at least one digit over the previous day.

Results of the intervention showed that students in both classrooms improved significantly in their acquisition of subtraction fact fluency (d = 2.05, 2.08). The difference in improvement between the two classrooms was not significant, indicating that the prospect of daily rewards did not increase learning rates. The authors posited this might have been due to the fact that TP has sufficient

reinforcement embedded into the intervention. Immediate feedback following student response may serve as positive reinforcement if the student's answer was correct. Students may also be motivated to race one another or themselves by attempting to beat their previous performance. Thus it appears that the external rewards presented to one classroom were secondary to other rewards such as intrinsic motivation, competition, and positive reinforcement experienced by both classrooms (McCallum et al., 2010).

Krohn et al. (2012) implemented the taped-numbers (TN) intervention to improve the number identification accuracy of four kindergarten students. This study was implemented using a multiple-baseline design. The first student to complete the baseline phase received his first day of intervention individually. After that, a new student joined the intervention each day to form a small group. The TN intervention was delivered by a tape that included a 1-second-tone to signal the start of the trial, followed by a 2-second delay for the student to attempt to read the number aloud. The number was read aloud in English at the end of the 2-second delay and students were asked to repeat the word. The next trial started 2 seconds later with the 1-second-tone. Sessions were implemented 3 days per week and each session included 40 total trials of numbers 0 through 9 presented in random order on a worksheet that corresponded with the tape. Each session lasted about 3 to 4 minutes. Afterward, students were assessed individually using worksheets that contained numbers 0 through 9 in random order. Students were given up to 5 seconds to read each number on the worksheet. The TN intervention was concluded for each participant when they achieved 100% accuracy on three of four

consecutive assessments. Students then participated in maintenance assessments. One student did not meet criteria after 12 sessions. Due to his variable performance, researchers supplemented the intervention with performance feedback, overcorrection, and reinforcement. After the additional of these components, the student reached criteria after five sessions.

The percentage of nonoverlapping data points equaled 100% for all participants except one, who had 86% nonoverlapping data points from baseline to intervention phase. Limitations of this study included the absence of data on responding collected during the TN intervention sessions, which makes it difficult to discern the behavior mechanism responsible for change. For example, it is unclear whether active responding during TN was necessary for improvement or whether learning occurred as simply a result of exposure. Researchers noted that the study did not measure the impact of the small group format and its potential impact on students' performance (Krohn, et al., 2012). This replication further supports the use of the time-delay taped-problems interventions as an early intervention to target basic academic skills.

Todd (2010) explored the use of an iPod to deliver a progressive time-delay taped-problems intervention to increase the multiplication fact fluency of four third-grade students. This study utilized a multiple baseline design across participants. Prior to the implementation of the intervention, participants had mastered less than 25% of multiplication facts 2 through 9. During the intervention, participants had a worksheet with 15 multiplication facts that corresponded to tracks on the iPod presented at three differing time-delays. Participants were first presented with a 1-

second time-delay, followed by a 4-second time-delay, and finally a 2-second time-delay. During each time-delay participants were instructed to "beat the iPod" by attempting to write their answer on the corresponding worksheet before they heard the answer on the iPod. Participants were required to reach a mastery of 80% correct on three consecutive trials before moving onto a new set of multiplication problems. The percentage of correct problems was used as the dependent variable.

The researcher found that overall the intervention was highly effective as measured by effect sizes (5.33) and percentage of nonoverlapping data points (96.75%), however, there was variability among participants. This intervention was highly acceptable to both the teacher and students alike. The researcher touted the ability for the intervention to be implemented independently by students and the students' inherent interest in the iPod as factors that make this intervention "classroom friendly" (Todd, 2010).

Mills (2011) replicated this study using an iPod to deliver a progressive time-delay intervention to increase multiplication fact fluency. The researcher extended the subject pool to include students with and without symptoms of inattention. The intervention was implemented during an after school program. Results indicated overall gains for all participants with an average effect size of 9.55. This intervention was acceptable by both teachers and students. This study provided further evidence for the use of the time-delay intervention using a mobile device to increase students' fact fluency.

Pummel (2011) extended the research examining the utility of an iPod to deliver a time-delay taped-words intervention to increase the sight word accuracy

of repeated reading students. A multiple-baseline design was used to implement this intervention to four second-grade students at risk for reading difficulties. The intervention was implemented using worksheets and iPod tracks. Each worksheet corresponded to an iPod track at 1-second, 4-second, and 2-second time-delays. The order of the words was randomized across each time-delay. The students were encouraged to "beat the iPod" by reading the word aloud from the worksheet before hearing the correct pronunciation from the iPod. Participants were trained to collect their own data by circling the word on the worksheet if they were correct or crossing it off if they were incorrect. To ensure treatment fidelity, the researcher was present across all intervention sessions. The percentage of words read correctly on the 2-second time-delay served as the main dependent variable. The average percentage of nonoverlapping data points for all participants was 90.8% and the average effect size was 1.98. These data indicate that the time-delay taped-words intervention delivered by an iPod is effective at increasing sight word accuracy. In addition, this progress generalized to an increase in oral reading fluency scores for all participants.

Nist and Joseph (2008) compared the effectiveness and efficiency of three reading interventions designed to improve reading performance. The interventions included traditional drill and practice, interspersal training, and incremental rehearsal. The interspersal procedure is a flashcard drill and practice method that incorporates both known and unknown words. Incremental rehearsal is a type of interspersal technique that involves multiple presentations of the same unknown word followed by an increasing succession of known words. Once the unknown

word has been practiced by incrementally adding up to nine known words, the ninth known word is replaced by the unknown word. The unknown word is now considered a known word and a new trial begins with a new unknown word. Efficiency of the intervention was defined as the rate of words learned and was calculated per session. The examiner used a stopwatch and began timing as soon as the first word was presented and stopped timing after the last word was read aloud by the student. Effectiveness of the intervention was defined as the cumulative number of words read correctly on the next-day retention probes.

Results indicated that under the incremental rehearsal condition, participants as a group read more words accurately and maintained more words 5 days after the experiment had ended. However, this condition was the least efficient. Students read the most words per minute of instructional time under the traditional drill and practice condition (Nist & Joseph, 2008). Traditional drill and practice procedures, however, possess possible limitations that limit viability, such as high levels of individualized attention from teachers, and students may not find them as enjoyable as other methods (Grafman & Cates, 2010). Thus, teachers may choose to implement procedures that do not require as much one-on-one attention but still provide multiple opportunities to respond and give feedback, and are enjoyable and engaging for students.

Cover, copy, compare (CCC) intervention is a self-managed intervention that can be used across a variety of academic skills such as math and spelling (Rathvon, 2008). Researchers McGuigan (1975) and Hansen (1978) first described CCC as a method to improve spelling performance (as cited by Joseph, Konrad, Cates, Vajcner,

Eveleigh, & Fishley, 2012). Skinner, Turco, Beatty, and Rasavage (1989) adapted the intervention to increase students' multiplication performance. Used as a spelling intervention, the student studies the correct spelling of a target word, covers the target word and writes it from memory. The student then uncovers the target word and compares their written word to the target word. If the student is correct, he proceeds to the next target word. If the student's word is incorrect, he repeats the CCC procedure (e.g., Joseph, et al., 2012; Rathvon, 2008).

This intervention is appropriate as either a Tier 1 or Tier 2 intervention, as it can be implemented with a group of students (e.g., Grafman & Cates, 2010) or individually (e.g., Erion, Davenport, Rodax, Scholl, & Hardy, 2009) (Vannest et al., 2010). It includes several components of effective academic interventions, including multiple opportunities to respond, active student engagement, and immediate and corrective feedback (Grafman & Cates, 2010; Rathvon, 2008). Joseph, et al. (2012) conducted a meta-analysis of 31 studies of CCC and its variations. Results, as measured by the percentages of nonoverlapping data (PND), demonstrated that overall, participants with and without disabilities responded positively to CCC. Interestingly, results further showed that participants with disabilities had a higher overall PND across all variations of PND than participants without disabilities. Authors also indicated that studies that coupled CCC with other evidence-based practices, such as opportunities to respond and token economies, had better results.

Conley, Derby, Roberts-Gwinn, Weber, and McLaughlin (2004) compared the effectiveness of a picture-word matching method to the CCC method to teach sight word recognition. Five kindergarten students, identified by their teacher as

displaying delays in reading, were participants in the study. In the picture-word matching condition, students began the intervention by playing a matching game with the researcher. Students were given five note cards. On each card was either a low-frequency sight word or a picture of a low-frequency sight word. The researcher held five corresponding note cards. The researcher presented a note card and asked the student to match it with the corresponding picture or word from their stack. The student was then asked to read the word. The game continued with the same five words until the student matched each target word to the corresponding picture with 100% accuracy. The researcher then added one new low-frequency sight word and corresponding picture to the stack. Play continued until the student could identify all words with 100% accuracy across three training trials.

In the CCC condition, students were given a piece of paper divided into three sections. In the first section, five low-frequency sight words were written with uppercase letters. In the second section the word was written with dashed lines and students were asked to trace the words. The third section was blank and students were instructed to trace the words and then write them on their own. They were also asked to say the letter names out loud as they wrote them and then read the word before beginning the same procedure with the next word. This teaching sequence continued until the student was able to correctly identify all five words across three straight trials. A new page of five words was then presented that contained two to three previously mastered words. These procedures continued until all target words were mastered at 100% across three training trials (Conley, et

al., 2004).

Results of this study showed that students identified more words in isolation after being taught the CCC method rather than the picture-word matching method. Furthermore, results were maintained at 1 week follow-up. In contrast, students taught using the picture-matching method misidentified words once the pictures were removed. Researchers noted this trend was consistent with previous research and posited that the pictures may be a distraction or that students may over-rely on the pictures to identify words. The authors noted that a limitation of the CCC was that the amount of instructional time used was twice as long as in the picture-word matching method. Both methods require the assistance of a teacher or tutor to provide feedback. Although the CCC method allows the student to check the written model for accuracy, it does not provide feedback regarding the student's ability to read the word aloud correctly (Conley et al., 2004).

Vannest et al. (2010) reviewed three studies to assess the effectiveness of CCC and found that it increased rates of correct responding and accuracy with a mean of 73% for students with EBD. Furthermore, when CCC was paired with a verbal response, accuracy and fluency increased for two boys with behavior disorders. These interventions provide further evidence for the utility of CCC as an academic intervention for sight words.

Poncy, Skinner, and Jaspers (2007) compared the effectiveness of TP and CCC at increasing a student's math fact fluency and accuracy. The student was a 10-year-old girl with moderate mental retardation whose teacher had requested services to increase her accuracy and fluency in basic addition facts. The student was taught to

independently complete the interventions. The CCC intervention also contained a verbalization component. Both interventions were effective at increasing the student's accuracy and fluency, but the TP intervention required less time to complete. Thus, researchers concluded that TP was superior to CCC due to the combined efficiency and effectiveness of the intervention.

Grafman and Cates (2010) extended the research on CCC and math facts. The study compared the effectiveness of CCC with a modified CCC (MCCC) procedure called Copy, Cover, and Compare. The MCCC procedure required the student to first copy the problem while viewing the target problem and correct the answer before covering it and engaging in the standard CCC procedure. This study extended the research of CCC to include subtraction problems and sought to determine which procedure was most effective, efficient, and desirable to teachers and students. Interventions were implemented within two second-grade general education classrooms. Results indicated that both procedures were effective at increasing fluency, but that subtraction fluency scores were significantly higher under the CCC procedure. Students preferred the CCC procedure while teachers preferred the MCCC procedure. These results further validated the use of CCC to enhance academic fluency skills and provided evidence for its utility in general education classrooms.

Repeated reading is an intervention that has been evaluated extensively in the research literature. What Works Clearinghouse (WWC) Intervention Report (2014) found 194 studies that investigated the effects of repeated reading on students with learning disabilities. Repeated reading is based on a theory of

automaticity and is used to increase a student's reading fluency and thus improve comprehension (Mastropieri, Leinart, & Scruggs, 1999; WWC, 2014). In this method, students are given short passages that contain common words that most students would recognize with ease. The student reads the passage several times until a determined level of fluency is attained and is then given another passage and the process is repeated (Mastropieri et al.,1999). Begeny, Krouse, Ross, and Mitchell (2009) compared the effectiveness of repeated reading, listening passage preview, and listening-only strategies on second-grade students' reading fluency. The interventions were administered in a small-group setting and results were calculated based on an increase in WCPM. Results indicated that both repeated readings and listening passage preview were effective at improving students' reading fluency over listening-only strategies or no intervention.

Although research has shown repeated reading to be effective in improving reading fluency, a review conducted by Chard et al. (2009) failed to classify repeated readings as evidence-based practice for students with or at-risk for learning disabilities. Their conclusion is largely based on the small number of research studies that meet standards to be considered high quality. Despite their inability to classify repeated reading as evidence-based practice, the authors noted that review of meta-analyses revealed positive effect-sizes associated with repeated reading. In addition, they contend that the theoretical framework surrounding the explanation of the role of fluency on reading proficiency provides support, at least intuitively, for repeated reading as an intervention to improve reading fluency. What Works Clearinghouse Intervention Report (2014) found repeated readings to have

"potentially positive" effects on reading comprehension, but "no discernable effect" on reading fluency. However, this may be due to the small number (*n*=2) of studies that met WWC group design standards without reservations.

Another method intended to increase reading fluency is previewing, also called listening previewing or passage previewing. This intervention can be used at the Tier 2 or 3 level of an RTI model (Vannest et al., 2010). Previewing allows for pre-exposure to text materials before the passage is actually read. The student can preview the material aloud, silently, or by listening to the teacher or a peer preview the material (Mastropieri et al., 1999). Listening previewing has been found superior to silent previewing in increasing reading fluency. In addition to fluency, this reading intervention promotes vocabulary acquisition and comprehension (Rathvon, 2008). Vannest et al. (2010) reviewed five studies that utilized previewing as an intervention for students with EBD. They calculated the effectiveness of the intervention and found that accuracy on reading and spelling lists increased by 71% on average.

Peer tutoring is an intervention strategy that can be used to improve reading accuracy, fluency, and comprehension by providing structured oral reading practice as students work in pairs (Fuchs, Fuchs, & Burish, 2000; Rathvon, 2008; What Works Clearinghouse, 2012). Peer tutoring may also be referred to as classwide peer tutoring (CWPT) or *Peer-Assisted Learning Strategies* (PALS) or *Peer-Assisted Literacy Strategies* (PALS) (e.g. Mastropieri, et al., 1999; What Works Clearinghouse, 2012). Fuchs et al. (2000) have stated that the "purpose of PALS is to strengthen the general education's capacity to meet the academic needs of a broader range of

children" (p. 85). These researchers suggest the use of peer tutoring to address the needs of students with diverse instructional needs and to provide students with a collaborative learning environment.

Students participating in peer tutoring work in pairs and alternate roles as the tutor and tutee. During these structured activities the pairs take turns reading aloud, listening to their partner read, and providing feedback. The students are trained to use learning strategies such as passage reading with partners ("Partner Reading"), describing the main idea of a paragraph ("Paragraph Shrinking"), and predicting ("Prediction Relay")(Fuchs et al., 2000; What Works Clearinghouse, 2012). Weak readers may be paired with more proficient readers in order to provide the weaker reader with a fluent reading model (Fuchs, et al., 2000; Rathvon, 2008). The higher performing student reads first in order to provide a model for the lower performing student (Fuchs et al., 2000).

What Works Clearinghouse (WWC) investigated studies that examined the effects of PALS on beginning readers. Two studies were examined that met the WWC evidence standards as randomized controlled trials (McMaster, Fuchs, Fuchs, & Compton, 2005; Stein, Berends, Fuchs, McMaster, Saenz, Yen, & Compton, 2008). Results of these interventions were mixed; from no statistically significant difference between the PALS group and the comparison across seven alphabetic domains (McMaster et al., 2005), to statistically significant differences between three PALS groups and a comparison on Rapid Letter Sounds for kindergarten students (Stein et al., 2008). Overall, WWC indicated that PALS has potentially positive effects with a medium to large extent of evidence and no substantially

important negative effect (What Works Clearinghouse, 2012).

What Works Clearinghouse (2007) reviewed PALS interventions for English language learners across three outcome domains: reading achievement, mathematics achievement, and English language development. One randomized controlled trial of PALS met evidence standards without reservation (Saenz, Fuchs, & Fuchs, 2005). According to this investigation the WWC rated PALS' extent of evidence to be small, but have potentially positive effects on reading achievement for English Language Learners.

Reading racetracks is an academic intervention intended to increase sight word fluency. Researchers compared the effectiveness of reading racetracks compared to list drills. Participants included eight second-grade students identified as at risk for reading difficulties. Students were given a pretest at the beginning of the study that included 218 Dolch sight words. Students' responses were recorded as correct if they read the word within 3 seconds. Unknown words were used as target words for the intervention. Unknown words were assigned randomly to either the racetrack or list drill condition. Words were then divided into seven-word sets. The study used a modified repeated acquisition design to compare rates of sight word acquisition between the racetrack and list drill formats. The number of trials was held constant under each condition. The sequence of condition was determined randomly at the start of each session (Sullivan, Konrad, Joseph, & Luu, 2013).

In this study, the reading racetrack consisted of 28 cells that formed an oval-shaped track. Each cell contained one of seven words, each word repeated four

times, distributed randomly around the track. The student was told where to start on the track and could proceed in a clockwise or counterclockwise manner. Students were prompted to move to the next word if they took longer than 3 seconds to respond. At the end of each one-minute trial corrective feedback was provided for any incorrect responses. Racetrack trials were repeated three more times and the highest correct score was reported to the student. The list drill condition procedures were conducted identically to the racetrack, but words were printed vertically in a list rather than on a racetrack. The dependent variable for the study was the total number of correct and incorrect Dolch sight words read orally per minute (Sullivan et al., 2013). Results were reported as average number of words read correct and incorrect per minute for each student across condition. Results varied by individual but overall indicated that as a group, students read more words per minute under the racetrack condition. The error rate was similar across conditions. Results from this study are limited given that they did not collect post-test, generalization or maintenance data.

Recent research investigated the use of video self-modeling (VSM) to improve the reading responsiveness of students who had demonstrated poor response to Tier 2 interventions. VSM involves the video recording and editing of a student performing a target behavior. The target behavior identifies a behavior or skill that is desired or slightly beyond the student's current ability. Researchers implemented a VSM using a single subject, multiple baseline AB design. Subjects included 10 first-grade students who had previously received 15 weeks of Tier 2 intervention but continued to demonstrate minimal progress decoding words and

recognizing sight words. Students continued their Tier 2 intervention program while concurrently receiving VSM 4 days per week for up to 8 weeks (Ayala & O'Connor, 2013).

Baseline data, progress, and maintenance effects were measured across three dependent variables: DIBELS Nonsense Word Fluency (NWF) probes, decodable words, and sight words. NWF scores were calculated by counting words read correctly (WRC) per minute. Two curriculum-based measurements included card sets comprised of decodable words and sight words of taught and untaught words from the Tier 2 lessons. Students were progress monitored twice weekly across all three measures. Sight words were presented as flash cards and students were given one minute to read as many words as they could. The entire set of decodable words was presented at each progress-monitoring session. Decodable words were presented as flash cards and students were given up to 5 seconds to read each word (Ayala & O'Connor, 2013).

To implement the VSM intervention, three to four 2-minute videos were made for each student. The videos were edited to show the student correctly decoding words and recognizing sight words. In addition to removing the researchers' prompting and modeling, editing allowed for the addition of still photos, graphics, titles, and sound as necessary. Each video included five decodable words and five sight words. The student segmented each decodable word and then blended each back together and read each sight word (Ayala & O'Connor, 2013).

The study was conducted using a multiple-baseline design yoked by groups of two or three students. Once a stable baseline had been established for the first

group of students, video recording was initiated for the VSM phase. Individual videos were recorded and edited. Students watched their 2-minute video on a computer at the beginning of their Tier 2 session. Once criteria for change, two data points above baseline, was met for at least two students in the group, video recording was initiated for the second group and the first group of students recorded their second instructional video. This pattern continued throughout the VSM intervention for all four groups. Once students had recorded more than one video they were given the option to watch any or all of their videos during the VSM session prior to their Tier 2 session. Students were also given copies of their videos to watch upon request in their classroom or at home (Ayala & O'Connor, 2013).

Percentage of nonoverlapping Data (PND) was used to determine intervention effectiveness. PND ranged from 70% to 100% across all three dependent variables for all students except one on each measure. Therefore, overall intervention effectiveness was judged to be effective to very effective for all students. Researchers concluded that VSM is a personalized Tier 3 intervention that involves a multifaceted approach. They hypothesize that the use of technology in addition to the excitement of watching themselves on the video may have improved interest and contributed to the students' feelings of self-efficacy toward reading since it allowed them to view themselves as successful readers (Ayala & O'Connor, 2013).

Montgomerie, Little, and Akin-Little (2014) examined the effectiveness of using VSM to improve the oral reading fluency (ORF) of four elementary students. They employed a multiple-baseline-across-subjects design. The VSM procedure was

implemented using edited videos of the students reading a passage slightly more difficult than passages presented during the baseline, intervention, and maintenance phases. Students were assessed through these phases using ORF probes, and the number of words read correctly (WRC) per minute was used as the dependent variable. During the intervention phase, students were shown their video before school for 2 weeks. Data were analyzed using visual analysis and PND. Two students' PND were 100% from baseline to intervention, which is considered very effective. However, the other two students scores fell in the ineffective range. PND were computed using baseline scores compared to maintenance scores. One student's PND was 91, indicating that overall this intervention was very effective at increasing his reading fluency. The other students' data ranged from ineffective to questionable to effective. Researchers noted the potential for VSM as an effective intervention for some students, however, they also noted limitations in the maintenance of effects. Authors posited that the combination of VSM and tutoring might produce more lasting effects than VSM alone. The authors also noted that most students were excited to watch their videos. This may increase students' motivation to complete the intervention and self-efficacy toward reading.

Students, Technology, and Education

Most students today are already regular consumers of technology. The average age a child first uses a computer is 3 ½ years old (Common Sense Media, 2011). According to the U.S. Department of Education (2004), 90% of children between the ages of 5 and 17 use computers. Similarly, Common Sense Media

(2011) found that 90% of children between the ages of 5- and 8-years old have used a computer and over half have used a mobile device to watch videos, movies, or to play games. The availability and usage of smartphones are on the rise as well. Project Tomorrow (2013) found that 65% of students in grades 6-8 and 80% of students in grade 9-12 are smartphone users. The report also found that percentage of middle school students with tablets jumped from 26% to 52% in one year. Between the years 2000 to 2002, the largest group of new internet users was children 2 to 5 years old (U.S. Department of Education, 2004). It is no doubt that the presence of technology, mobile devices in particular, will continue to become more prevalent in the lives of children as it becomes more affordable and available for a variety of uses. These statistics show that most children already access computers and mobile devices for entertainment. Therefore, researchers and educators must harness the academic potential of mobile devices and make it entertaining in order to impact the lives of both students and teachers. Smith and Okolo (2010) stated: "One way to further technology use is to examine what we know about effective instructional practices and link the critical features of these practices with technology-based solutions" (p. 258).

The use of technology has almost infinite possibilities to educate children. Author Malcolm Gladwell noted that the success of the iconic children's television show Sesame Street was built around the notion that "if you can hold the attention of children, you can educate them" (2000). Today, we are well beyond using only television or computers to effectively enhance instruction and learning. Technology is more readily available than ever and the implications for education are just

beginning to surface. In particular, apps have high potential to become a mainstream medium in education both for their availability and popularity. "Children's apps are a growing market, and should be considered an important one for developers, researchers, investors, and policy makers," (Shuler, 2012, p.13).

An "app" is a software application designed for use on a mobile device operating system, which extends that device's capabilities. Apps are available for a wide variety of interests, including, health, shopping, entertainment, education, and navigation. Apps were first introduced in 2007 with the Apple iPhone. They are currently used on other smartphone platforms and tablet computers (Purcell, 2011). The iPad, Kindle Fire, and Nook are just a few examples of mobile devices that have the ripe potential to impact education. These devices are convenient, user-friendly, trendy, and desirable, and each offer a wide assortment of apps.

Parents are more likely than nonparents to download apps to their tablets and mobile devices. Furthermore, 57% of app-using parents had downloaded an app for use by a child, and 31% of adults who downloaded an app for a child reported that the app was oriented around learning or education (Lenhart, 2012). As noted, children seem to be inherently drawn to technology for entertainment, and parents are interested in using it enhance their child's knowledge and engage them in learning.

Looking further into the growing interest in educational apps for children, Shuler (2012) conducted an analysis of the Education category of Apple's app store and found that over 80% of the top-selling apps in the Education category of iTunes targeted children. Sixty percent of the top 25 of these apps targeted

toddler/preschool children. Interestingly, only 20% of the 200 top-selling iTunes educational apps targeted elementary-aged children, yet comprised nearly 50% of the 25 top-selling apps. This indicates that the creation of educational apps for elementary-aged children is highly desired yet underdeveloped. Furthermore, Shuler (2012) noted that literacy apps might be an underrepresented market, and thus, an important area of opportunity for developers.

Technology in the Classroom

In November of 2010, the U. S. Department of Education released their National Education Technology Plan, entitled *Transforming American Education: Learning Powered by Technology*. The letter to congress stated: "The plan calls for applying the advanced technologies used in our daily personal and professional lives to our entire educational system to improve student learning, accelerate and scale up the adoption of effective practices, and use data and information for continuous improvement" (p. v). In this plan, they identified five essential areas with goals and recommendations including learning, assessment, teaching, infrastructure, and productivity. The plan acknowledged that the challenge for our education system is to create "engaging, relevant, and personalized learning experiences for all learners that mirror students' daily lives and the reality of their futures" (p. x).

As outlined by the Department of Education's plan, the incorporation of technology into students' education will only be successful if it is engaging, fits naturally within their daily life, creates occasions to enhance and enrich their

experiences, and utilizes data to assess growth and inform practices. In order to ensure that technology is used as a supplement and not a distraction from students' education, it is important to consider past research findings including variables of technology that have been shown to enhance learning, engage students, and inform practice. Furthermore, as rapid advances in technology are inevitable, the greatest challenge will be for research to stay current and applicable to the changes in order to inform practice of the most effective and efficient ways to utilize technology.

Smith and Okolo (2010) stated: "Technology-based applications can deliver instructional activities that reiterate and provide practice in the basic skills with which students often struggle" (p. 269). Technology is best used for explicit instruction in skills that have already been taught in more traditional ways and thus provides additional instruction, enrichment, review, and practice. Features of explicit instruction that are best supported by existing technology include: increased practice in basic skills, increased academic learning time, feedback and review, and systematic progress-monitoring (Smith & Okolo, 2010). The use of technology can be an effective and efficient way for classroom teachers to supplement instruction and implement academic interventions. Shuler (2012) noted: "Today's children will benefit if apps become an important force for learning and discovery" (p. 2).

The use of computers to assist instruction is typically considered a Tier 2 intervention (Vannest et al., 2010). Research has shown that computers and computer programs are efficient and effective ways to deliver academic and behavioral interventions. For example, Mastropieri et al. (1999) suggested that

computers could be used to effectively provide practice to improve reading fluency as well as measure students' reading abilities. Computer-based sight-word reading interventions (CBSWRI) were designed to address concerns related to students' attention and motivation by using computers to enhance motivation, occasion high rates of responding, and provide prompts to serve as feedback (Yaw, Skinner, Parkhurst, Taylor, Booher, & Chambers, 2011). Dawson, Venn, and Gunter (2000) examined three instructional modifications to teach students with EBD to read. Researchers found that while the use of a teacher model was the most effective at increasing the number of words read correctly, using a computer model was more effective than no model (as cited in Vannest et al., 2010). Ayala and O'Connor (2013) used computers to implement a Tier 3 video self-modeling intervention that successfully improved students' word decoding and sight word recognition. The use of a computer allowed the students to receive an efficient, effective, and personalized Tier 3 intervention while still maintaining participation in their Tier 1 reading instruction and Tier 2 reading group. Furthermore, the researchers pointed to the potential for technology to offer additional intervention support outside of school time.

Rabiner, Murray, Skinner, and Malone (2010) conducted a randomized trial of two computer-based interventions for students who experience difficulties with attention. The researchers examined computerized attention training (CAT) and computer-assisted instruction (CAI). CAT used computers to present exercises where success was dependent on the ability to sustain attention and respond based on clearly defined rules. During the training, the exercises became more challenging

and demands on attention increased, therefore providing structured practice in learning to attend. CAI presented academic material via a computer using instructional features to improve performance in children with short attention spans. Instructional features included providing immediate and frequent feedback, reinforcement, and highlighting important information. Results indicated that approximately 50% of the first-grade participants showed declines in attention difficulties and nearly 25% of participants had inattentive scores within the normal range following the intervention.

Yaw et al. (2011) conducted a multiple-baseline-across-tasks design with a sixth-grade student diagnosed with autism to increase sight word accuracy. The researchers used a computer-based sight-word reading system (CBSWRS) to deliver the intervention. Three word lists of 10 words each were teacher-selected from primer and first-grade Dolch words that the student did not know how to read. Words read correctly within 2 seconds were scored as correct during the baseline sessions. The intervention was conducted 2 to 4 days per school week and the student was assessed on each word list immediately after each intervention session. Microsoft PowerPoint and Apple GarageBand were used to create the computer-based intervention which presented each sight word for 2 seconds in a PowerPoint. After the sight word disappeared the student heard the primary researcher's voice recording of the sight word followed by another 2-second delay in which the student was instructed to repeat the word aloud. Sight words that were read aloud before the sight word disappeared from the screen were scored as correct. The student's responses were recorded on GarageBand and scored by another

researcher to calculate interobserver agreement data. Results showed that the student read 0 to 1 words correctly on baseline assessments. Accuracy was increased to at least 4 words up to 9 words correct per intervention session. In addition, the student's sight word accuracy actually enhanced across maintenance trials. The student read 25/30 words correctly on the final assessment trial. The researchers concluded that using a computer-based sight-word reading intervention is an efficient and effective way to increase sight-word automaticity in a student with autism.

Gibson, Cartledge, Keyes, and Yawn (2014) investigated the effects of a repeated reading computerized intervention program (Read Naturally) on the oral reading fluency (ORF) and comprehension on generalization passages for eight first-grade students at risk for reading difficulties. This study utilized a multiple-probe experimental design with two treatment phases. All participants continued to receive daily classroom reading instruction in addition to this intervention.

Read Naturally is a commercial computerized reading program that utilizes a multicomponent repeated reading strategy. Each intervention session of the Read Naturally computer program included instruction of three to four key words, a 1-minute cold reading of the treatment story, a read along of the treatment story with the computer, and practice of 1-minute repeated readings of the treatment story until a set criterion goal is achieved. After achieving the goal, participants went on to complete a comprehension test that asked multiple-choice and short-answer questions about the story. Lastly, participants complete a pass timing reading probe with the teacher. Throughout the program, students are instructed to read aloud

quietly, to mark words they do not know, and to mark the last word read at the end of the 1-minute timings (Gibson, et al., 2014).

Phase 1 of the intervention design included students using the Read Naturally program until they reached a predetermined oral reading fluency goal of 40 words read correctly per minute. Phase 2 was implemented identically to Phase 1, but goals were based on their individual performance in Phase 1. Results of the intervention included increases in ORF and word retell fluency (WRF) on training and generalization passages. However, satisfactory generalization did not occur until the second phase was implemented. The authors attributed this change to the increase in effort required by participants to reach their goal and receive the natural contingency of reinforcement. Procedural integrity data were collected that focused on the participants' abilities to complete steps correctly. Percentages ranged from 66% to 100%, with an average of 85%. The authors noted that the most common errors included the participants not clicking on unknown words and/or not following along during the read along. However, as gains were observed for all participants, the researchers underscored the potential of computer-based programs to serve as delivery mechanisms for efficient and effective supplemental instruction, especially for students at risk for academic failure when other supports would not otherwise be available (Gibson et al., 2014).

Research exploring the utility of mobile devices such as iPods and iPads as academic and behavioral intervention tools is still in it infancy. Nonetheless, this is an area of incredible promise and importance for educational researchers. USA Today (2011) reported that iPads are "growing in popularity [with educators and

parents] for special-needs students because they can be easily customized to each child's needs, are lightweight and mobile, and give the kids the sense they're plugged into a larger, high-tech community." Another advantage of mobile devices, such as iPods and iPads, is that they do not set students with special needs apart from their peers, like communication or other assistive devices do, because they are also used by typically developing children.

Coleman, Cherry, Moore, Park, and Cihak (2015) explored intervention effectiveness and efficiency between teacher-directed (TDSP) and computer-assisted simultaneous prompting (CASP) instruction to teach sight words to three elementary students with intellectual disabilities. Participants were in the fourth grade in a self-contained classroom. The study used an alternating treatment design where all students received both conditions, one per day. The order of conditions was randomized with neither condition occurring for more than two consecutive days. Students were presented with five unknown words in each condition.

The TDSP instruction was presented one-to-one. The teacher presented a sight word and immediately said: "This word is ___. What word is this?" The student was expected to repeat the word. Accuracy was praised and incorrect responses were followed with correction. The CASP condition utilized a computer software program that presented words in a similar manner. The target word appeared on the screen and the program said the word simultaneously. Three word choices appeared at the bottom of the screen and participants selected a word from the choices while saying the word aloud. Correct responses were followed by a screen that said, "Yay!" with a graphic. When an incorrect response was made, the incorrect

word was spoken. The next target word was then presented (Coleman et al., 2015).

The alternating-treatment phase continued for each participant until criterion was met in one condition. Criterion was set at three consecutive sessions with scores of 80% (or higher), 100%, and 100% (in any order). Once criterion was met for one condition, this was assumed to be the preferred condition and all instructional sessions continued using the preferred condition. Results indicated that both conditions were effective at teaching sight words, but found the teacher-directed condition to be more efficient for two students. Conditions were equally efficient for the third student, but the teacher-directed condition was preferred. Authors highlighted the importance of considering individual student characteristics and preferences when choosing technology-based versus teacher-directed interventions. Researchers also noted that the computer-based intervention required more time to set up initially, but was easier to adapt and individualize for other students after the first version was created (Coleman et al., 2015).

Todd (2010) and Mills (2011) conducted studies that used an iPod to implement time-delay interventions to increase multiplication fact fluency. Results of these interventions suggest that this method of implementation was both effective and acceptable to teachers and students. Similarly, Pummel (2011) conducted a study that used an iPod Touch to implement a time-delay taped-words intervention to increase sight word accuracy to students with reading difficulties. All students made gains in sight word accuracy as well as oral reading fluency. Teachers and students found this intervention to be acceptable. Furthermore, these

studies provide evidence for the utility of mobile devices to implement effective academic interventions. Although researchers were present to ensure procedural fidelity, students in these studies were able to use the iPods to independently implement the intervention.

Buzhardt, Walker, Greenwood, and Heitzman-Powell (2012) identified another significant benefit to utilizing mobile devices: the ability to deliver information at the point of care. This is especially advantageous for intervention planning and delivery for infants and toddlers who receive services within their "natural environment." The primary caregiver plays a key role in the child's natural environment and functions as a primary facilitator of interventions. The ability to immediately share data with parents using mobile devices directly involves them in the intervention-planning process and may increase their sense of ownership in the decision making process and the likelihood they will implement the recommendations (Buzhardt et al., 2012). The use of apps on mobile devices creates a unique advantage for teachers and parents who wish to be partners in delivering intervention services for students. Due to the portability of mobile devices, students can receive intervention in their classroom and also at home. This allows the target skill to be generalized across settings as well as delivered consistently across caregivers, and includes both teacher and parent as part of the learning process.

Researchers have also explored the usability of mobile devices to deliver interventions and teach skills in order to meet students' academic, communication, and behavioral goals. Marks and Milne (2008) explored the utility of iPods as adaptive and emerging technology by using them to assist students with severe

intellectual and physical disabilities in meeting their individualized education program (IEP) goals. Students' goals were academic, behavioral, and social in nature. The iPods contained music, photographs, Picture Card Symbols, videos, spoken word, and social scripts in video, textual, and slide show formats. For example, the iPod was used with one student to create an individualized social story to teach proper hand washing. The iPod contained slide show pictures that depicted the student performing the necessary steps of hand washing. This method of intervention was successful at teaching the student the proper procedures for hand washing, whereas previous attempts to teach this skill were unsuccessful. In addition to its practical application, they found this technology to be motivating and have extrinsic value. For example, the researchers found the behavior of students with histories of challenging behaviors to improve contingent upon the opportunity to access the iPod during lunch recess.

Cihak, Fahrenkrog, Ayres, and Smith (2009) conducted a study to evaluate the efficacy of video-modeling delivered by an iPod to assist elementary students with autism in transitioning between locations and activities within the school. The researchers used an ABAB design to conduct the video-modeling intervention. Four elementary students diagnosed with autism participated in the intervention. All students had difficulty transitioning independently and displayed inappropriate behaviors such as aggression and running away when asked to transition. Results indicated that the video-modeling procedure was effective at increasing the percentage of independent transitions for all students. The mean percentage of independent transitions at baseline was 7%, compared to a mean percentage of

77% during intervention. When the intervention was withdrawn, descending trends were observed and the mean percentage across participants decreased to 36%. When reimplementation occurred, ascending trends were again observed and the mean percentage increased to 88%. The researchers concluded that this study provided further evidence for the use of self-modeling interventions to teach students new skills. They also advocated for the use of mobile devices in delivering this type of intervention because of its portability to be used in multiple settings within the school.

Similarly, Blood, Johnson, Ridenour, Simmons, and Crouch (2011) used an iPod Touch to implement a self-modeling and self-monitoring intervention to a 10-year-old elementary student with emotional and behavioral disorders. One goal of the research was to determine whether the use of an iPod to deliver the self-modeling intervention alone or with self-monitoring would increase the student's amount of appropriate behavior during small group instruction. In addition, the researchers sought to investigate the use of portable, hand-held technology to implement these interventions.

Dependent variables for this study included time on-task and the occurrence of disruptive behavior. A single-subject changing conditions (A-B-AB) design was used. Self-modeling was the first phase of the intervention. A four-minute self-modeling video was recorded of same-aged peers demonstrating appropriate math group behavior and included narration that described the behavior expectations. The participant watched this video daily before the beginning of the math group. During the second phase of the intervention, the participant was taught to self-

monitor their on- and off-task behavior using a paper and pencil tally sheet. The participant watched clips of himself exhibiting appropriate and inappropriate behavior and was taught to mark a "yes" or "no" dependent upon whether he was displaying the appropriate math group behavior. After this teaching trial was completed, phase 3 was implemented, which included self-modeling and self-monitoring components. The participant continued to watch the self-modeling video before math group sessions and in addition, self-monitored his own on- and off-task behavior as prompted by a timer on the iPod Touch (Blood et al., 2011).

The researchers found that the student's on-task behavior increased during the self-modeling phase, but was inconsistent. However, when self-monitoring and self-modeling interventions were implemented simultaneously, the participant's on-task behavior significantly and consistently improved. In addition, the student demonstrated consistently low levels of disruptive behavior. The researchers noted that the iPod Touch provided an efficient and portable means for delivering the self-monitoring intervention in addition to providing self-monitoring cues to the student (Blood et al., 2011).

McClanahan, Williams, Kennedy, and Tate (2012) conducted a case study with a fifth-grade student diagnosed with ADHD. The researchers utilized an iPad to deliver the intervention because, in addition to the general allure of the device, it offered the student a self-paced, individualized format. In addition to working with the student one-on-one, the researchers used iPad apps that utilized teaching strategies to teach word recognition and comprehension. The researcher also downloaded eBooks to the iPad, which allowed the student to record himself

reading and then listen to his recording as he followed along in the text. Graphic organizers were also downloaded to the iPad. Results of the intervention indicated that the student's instructional level increased by one grade level over the six-week intervention. The researchers credit the use of the iPad to the success that this student achieved, as past tutoring and intervention had not been successful at facilitating reading improvement. The ability to generalize the findings of this case study is limited due to the research methodology and design, however, this study points to several important factors when considering the potential utility of an iPad as an intervention tool. iPads are easy to use, captivate students' attention, provide virtually unlimited access to information and strategies, and have the ability to be individualized to meet each student's unique needs. The authors of this study stated that research aimed at how devices such as the iPad negatively or positively impact students who are at a disadvantage for learning in the traditional school setting is needed so that technology can be used to its highest advantage.

Kagohara, Sigafoos, Achmadi, O'Reilly, and Lancioni (2012) used an iPad to deliver an instructional video to teach two students with Autism Spectrum Disorders (ASD) to use the spell-check function on a word processor. The modeling video was recorded from a subjective viewpoint, as from the observer's perspective. A multiple-baseline design across participants was used to conduct the baseline, intervention, and follow-up phases. The dependent variable was the number of steps that were performed correctly during each session. Sessions were conducted one or two times per week per participant. The students began each intervention session by watching the video on the iPad and were then instructed to write five

spelling words using the spell-check function as illustrated by the video. Results of the intervention showed that both students used spell-check with 100% accuracy at follow-up. The results of this study further demonstrated the potential for mobile devices to deliver instructional strategies through video-modeling. For research and fidelity purposes, the researchers also noted that the use of an iPad allows for an intervention to be easily conducted in different schools or by different personnel and still retain procedural integrity. The researchers also commented that the students appeared to look forward to watching the video-modeling on the iPad. Participants were also given access to the iPad after each session, which may have increased their motivation to participate in the intervention.

Larabee, Burns, and McComas (2014) examined the effect of an iPad to increase task engagement and decoding performance for early elementary students at risk for reading failure. The use of an iPad-supported word box intervention was compared with implementation using standard materials. Participants included three six-year-old first-graders, two of whom were English Language Learners (ELL). Students were selected based on screening data and teacher recommendation. Screening data included benchmark assessments in letter naming fluency (LNF), letter sound fluency (LSF), nonsense word fluency (NWF), and oral reading fluency (ORF). Students scored below fall benchmark criterion on all three assessments.

The traditional word box intervention materials consist of a small magnetic white board with a rectangle and three boxes outlined within with black tape and lowercase, magnetic letters. The iPad condition utilized an existing iPad application

called, “Build A Word – Easy Spelling and Phonics.” The intervention aimed at teaching one letter sound per intervention session using a prespecified set of consonant-vowel-consonant (CVC) words. Each session involved using the word boxes to teach 7 to 10 CVC words containing the target sound. Researchers used a gradual release of responsibility approach to model the task, share the task with the student, and gradually guide the student toward completing the task (Larabee et al., 2014).

To implement the intervention, the researcher states the CVC word and the student is expected to slide each magnetic letter into the correct box while simultaneously saying the letter sound aloud. The student then runs their finger underneath the word and fluently blends the sounds to read the word. The student received corrective feedback during this process from the researcher. Intervention procedures were nearly identical between the traditional method and the iPad app. The order to presentation of intervention condition was randomly determined for each student and alternated across sessions. Intervention was delivered on 9 occasions across 3 weeks (Larabee et al., 2014).

To measure the effectiveness of the traditional word box compared to the iPad app, the number of correct letter sounds on a nonsense word fluency (NWF) probe was used as the dependent variable. NWF probes were created to focus on letter sounds that were taught during the sessions. Probes were administered and the time recorded for the students to read all the letter sounds or nonsense words was recorded and converted to letter sounds per minute. Student’s time on-task was also measured using a momentary time sampling (MTS) procedure with 10-second

intervals (Larabee et al., 2014).

Results of the effectiveness of the traditional word box versus the iPad app varied across participants. Results of the NWF probes revealed that two students seemed to benefit more from the instruction on the iPad, while one showed better results with the traditional implementation. Results of time on-task data showed that all students had high levels of engagement across both types of implementation, however, two students showed a decreasing time on-task trend in the traditional method (Larabee et al., 2014). Results of this study are generally inconclusive, however, they do provide evidence that students can benefit from research-based interventions delivered by an iPad application. Built-in features such as corrective feedback and modeling of word reading may prove useful for teachers searching for alternative methods of intervention when time constraints prevent the teacher from implementing teacher-led reading intervention. Additionally, it is possible that not all students will prefer the use of technology over traditional implementation or vice versa. Thus, teachers need to consider each student individually when incorporating technology into interventions. Authors noted that, given inconsistent results across study participants, findings are best used to inform future research practices with mobile devices (Larabee et al., 2014).

Researchers recently examined the use of an iPad app to improve the sight word reading fluency of first-grade students at risk for reading difficulties (Musti-Rao, Lo, & Plati, 2015). Research questions were answered through the implementation of two studies. Both studies implemented sight word reading intervention with the use of *The Sight Words: Kids Learn App* for iPad, developed by

Teacher Created Materials Publishing. Components of the app included the ability to read a word, listen to a word by touching it, write/copy the word, record the word with their own voice, and replay to hear the word. In addition, the app also contained activities, such as tic-tac-toe, that students could play to reinforce their learning after five words.

Dependent variables in Study 1 included the number of sight words read correctly in 1-minute (CWPM) in addition to three lists of 30 sight words created from the first 90 words taught by the iPad app. A multiple-baseline across behaviors (word lists) was nested within a multiple-baseline across participants design. Experimental conditions included baseline, teacher-directed iPad instruction, and maintenance. During baseline, students participated in their regular reading routing that consisted of independent reading, partner reading, and teacher-directed small group reading. During the intervention phase, the teacher targeted five words per session. The same words were repeated for three sessions a week and a new set of words was introduced each week. Using the iPad, the teacher prompted the student to listen to the word, say the word, write the word, record the word, listen to the recorded word, repeat the word, and then move onto the next word. This cycle was repeated 3 times for each word. After the cycle was complete the student was allowed to play the activity presented at the end of the instruction. This condition was implemented for 13 weeks. Number of sessions varied per student. Maintenance data were collected 3 weeks after iPad instruction. Results showed no overlapping data with the baseline condition on all word lists for all participants, and observed trend lines suggest positive treatment effects. However, only minimal

increases in oral reading fluency were observed for participants, suggesting that intervention effects did not generalize to connected text (Musti-Rao, et al., 2015).

Study 2 measured the effectiveness of self-mediated iPad instruction on sight word fluency, oral reading fluency, and academic engagement. Academic engagement was measured during independent reading time and self-mediated iPad time using momentary time-sampling procedure. Study procedures were similar to Study 1 with the exception that students were expected to mediate their own instructional time using the iPad. Expectations were identical to Study 1, with the exception that students learned 5 new words each instructional day after reviewing the 5 words from the previous day. Students were also expected to complete instructional logs that contained the words learned each day and have the teacher initial it. Trend lines indicated reliable treatment effects for all three students. A significant increase in oral reading fluency was only observed for one student. Rates of academic engagement continued to be variable during the independent reading observations. Academic engagement during the iPad condition, however was stable and showed high rates of engagement, with average rates higher than 95% for all participants (Musti-Rao et al., 2015).

Researchers pointed to the utility of interventions implemented by the iPad to increase the sight word reading of students. Researchers noted the discrepancy in academic engagement rates between the independent reading time and self-mediated iPad instruction. They noted that students who lack decoding skills are less likely to engage in reading activities independently. Thus, researchers suggested that mobile technology has the potential to provide students with

individualized learning experiences that maximize engagement and promote learning (Musti-Rao et al., 2015).

These studies point to the significant utility of mobile devices to assist students in the development of academic, behavioral, and communication skills needed to access their educational curriculum (e.g., Blood et al., 2011; Cihak et al., 2009; Gibson et al., 2014; Kagohara et al., 2012; Marks & Milne, 2008; McClanahan et al., 2012; Mills, 2011; Musti-Rao et al., 2015; Pummel, 2011; Rabiner et al., 2010; Todd, 2010; Yaw et al., 2011). Many features unique to mobile devices (e.g., access to data, individualization, portability) that may increase the efficiency and effectiveness of the intervention were also highlighted (e.g., Buzhardt et al., 2012; Marks and Milne, 2008; Musti-Rao, et al., 2015). In addition, mobile devices are able to deliver interventions using effective strategies, such as providing multiple opportunities to practice basic skills, modeling, and feedback (e.g., Dawson et al., 2000 as cited in Vannest et al., 2010; Smith & Okolo, 2010). Many researchers also noted that students appeared to have increased motivation to complete the tasks associated with the intervention due to the high desirability of the mobile device (e.g., Cihak et al., 2009; Kagohara et al., 2012).

"As a nation, we need to continue to think about, research, and debate the impact of media on young children. Media occupy such a substantial place in children's lives that we ignore it – or take it for granted – at our peril" (Common Sense Media, 2011, p.30). More research is needed to determine the areas in which technology can be used most appropriately, the students who would benefit, and to develop user-friendly, cost-effective, and time-efficient ways to tailor the material

presented. Furthermore, as noted by McClanahan et al. (2012), research aimed at how mobile devices negatively or positively impact students who are at a disadvantage for learning in the traditional school setting is needed so that technology can be used to its highest advantage. As previously demonstrated, access to the technology alone is likely to increase motivation in students, but that is not reason enough to incorporate new technology. Research must validate the use of technology and demonstrate its effectiveness at enhancing learning to prevent it from becoming an unnecessary distraction. In addition, researchers should create and study the effectiveness of apps that supplement instruction and provide remediation so that teachers have access to easy-to-use evidence-based interventions.

Statement of Purpose

The purpose of the current study was to empirically evaluate the effectiveness of a specifically designed iPad app to administer the time-delay taped-words intervention. The current intervention was targeted toward second-grade students who were in need of academic support at the Tier 2 and Tier 3 levels of a response to intervention model. The app was specifically designed by the researcher to contain components of effective academic interventions, such as repeated opportunities to respond and immediate and corrective feedback. In addition, the intervention utilized mobile technology, an iPad4, as the mode of delivery and data collection. This study aimed to add to research that has identified the time-delay taped-words intervention as an effective academic intervention as well as the

growing literature related to mobile devices as intervention tools. Furthermore, it was proposed that both teachers and students positively accept the iPad app as an efficient and effective way to supplement instruction.

Research Questions

1. Do students at risk for reading difficulties become more accurate at recognizing Instant Words through the use of this intervention?
    a. Demonstrated by average percentage correct from the baseline phase to the intervention phase.
    b. Significance as measured by Tau-U effect size.
2. Is accuracy maintained at follow-up?
    a. Measured by the average percent correct from the intervention phase to maintenance phase.
3. Was an increase in word reading observed?
    a. Measured as percentage correct by the pre- to post-intervention inventory of Fry's fifth 100 Instant Words (words 400-499).
4. Did intervention effects generalize across reading fluency measures?
    a. Comparison of DORF pre- and post-intervention.
    b. Comparison of WJ IV ACH reading clusters pre- and post-intervention.
5. Do teachers find this intervention acceptable, effective, and time-efficient?
    a. Measured by the mean of ratings on the Intervention Acceptability

– Teacher Rating Form?

6. Do students find this intervention acceptable, effective, and time-efficient?
    a. Measured by their ratings on the Intervention Acceptability – Student Rating Form?

METHODS

Participants

Participants were recruited during the 2014-2015 academic school year. The study was conducted in a public elementary school in Montana, where the experimenter is also employed as the school psychologist. The school is predominately white, with 332 students. Data from the 2013-2014 school year showed that 19.8% of students were eligible for free/reduced lunch. The maximum allowable class size for the repeated reading is 20 students. There are two second-grade classes and one combination second-third grade class. Permission to conduct the study was solicited by the experimenter and granted by both the school district and the University of Utah Institutional Review Board. A total of six students were chosen to participate.

Students in the repeated reading who met the eligibility requirements discussed below were eligible to participate in this study. In a broad sense, these students have demonstrated lower than expected performance within the area of reading fluency. They may or may not have received other interventions or support in attempt to remediate this deficit, but showed continued difficulty meeting grade-level expectations. Particularly, students who fall just below the identified benchmarks may fail to receive appropriate intervention. These students may "fall between the cracks" because their skills fall somewhere between students who

achieve without additional support and those who quality for specialized instruction.

Schools and teachers may not be adequately prepared to address the needs of these students due to lack of resources such as time, personnel, money, materials, or knowledge. Thus, the purpose of this study aimed to provide a resource that is easily accessible, easy to use, inexpensive, and did not require the teacher to use preparation time, sacrifice instructional time, or allocate additional personnel to implement. In addition, the empirical evaluation of this app adds to the extensive base of research-validated literature that describes the effectiveness of the time-delay taped-words intervention (e.g., Casey, 2008; Freeman & McLaughlin, 1984; McCallum, Skinner, & Hutchins, 2004; Todd, 2010) and adds to the small yet growing literature base that focuses on using mobile technology to improve student learning (e.g., Pummel, 2011; Todd, 2010).

Specific eligibility requirements for the current study included:

1. Students in the repeated reading.
2. Students who were referred by their teacher due to inadequate progress in reading.
    a. Teachers were asked to identify students who needed additional support in reading and/or who were at risk for "falling between the cracks" if they did not receive additional support in reading.
    b. Eleven students were referred.
3. Students who were referred were screened using the Dynamic Indicators of Basic Early Literacy Skills (DIBELS) Oral Reading Fluency (DORF)

(Good & Kaminski, 2002; Good, Kaminski, & Dill, 2007).

   a. DIBELS Oral Reading Fluency (DORF) is a standardized set of passages and administration procedures that is individually administered as a test of accuracy and fluency within connected text. DORF is designed to identify children who may need additional instructional support and to monitor progress toward instructional goals (Good, Kaminski, & Dill, 2002; Good, et al., 2007; Shinn & Shinn, 2002).
   b. Students who scored in the "intensive" need for support range of oral reading fluency on the end-of-year benchmark assessment (0 – 83 WCPM for repeated reading) as determined by the DIBELS Next Recommended Benchmark Goals (University of Oregon Center on Teaching and Learning, 2012) met the first eligibility requirement to participate.
      i. Nine students scored within the intensive need for support range.

4. Students who received parental permission to participate.
   a. A letter was sent to the parents of the student who were referred by their teacher and fell within the DORF "intensive" range. The letter and parent permission slips described the nature of the intervention, requirements for participation, and potential risks (Appendix A & B). The letter specifically indicated that permission did not guarantee participation in the study.

        i. Seven students received parental permission.

    b. Participants were given one calendar week to return the permission slips indicating their choice to opt in or out from the research study.

    c. Participants who had not returned permission slips within the calendar week were sent one additional letter and given one additional week to opt in to the study.

    d. Students who did not received parental permission were not eligible to participate.

        i. Two students did not receive parental permission.

5. Students who had *not* been identified as having a disability that required specialized instruction under IDEA 2004 had priority for participation in this study. These students may not meet special education criteria, yet still require reading fluency intervention. These students are at most risk for "falling through the cracks" if the necessary supports are not in place.

    a. None of the students who participated in the study were identified as having a disability under IDEA 2004.

    b. One participant was referred for a special education evaluation during the time of the study. Results of the evaluation indicated that the student did not qualify for special education services.

6. Participants were also screened using the San Diego Quick Assessment of Reading Ability (LaPray & Ramon, 1969).

    a. Participants who scored within the instructional or frustration

level for repeated reading met continued eligibility.

i. Six students scored within the second-grade frustrational and instructional levels.

7. Students with significant behavioral or emotional concerns were ineligible to participate.
    a. The Behavior Assessment System for Children, Second Edition (BASC-2) Teacher Rating Scales (TRS) (Reynolds & Kamphaus, 2004) was used to screen for significant behavioral or emotional problems.
    b. Each student's teacher completed a BASC-2 TRS as part of the eligibility requirement. Students whose scores fell within the acceptable range (T-score $\leq$69) on all composite scales (Internalizing Problems, Externalizing Problems, or the Behavioral Symptoms Index) were eligible to participate.
        i. All students' BASC-2 scores fell within the acceptable ranges.
    c. Students whose scores fell at or above a T-score of 70 within the composite scales (Internalizing Problems, Externalizing Problems, or the Behavioral Symptoms Index) were ineligible to participate.
8. Students who gave assent to participate (Appendix C).
    a. The assent form was read to each student by the researcher. It explained the purpose of the study, possible risks and benefit, as well as the voluntary nature of participation.

b. Six students met eligibility requirements and gave assent to participate.

Participants included two girls and four boys in the repeated reading. All participants were either seven- or eight-years-old. None of the students were in special education. One student was referred for a special education evaluation at the time of the study, but did not meet classification requirements as a student with a specific learning disability. Most of the students had received prior academic intervention in the form of small group reading instruction in addition to core instruction that utilized Lucy Calkin's reader's workshop model.

Each participant's classroom teacher was asked to participate in this study by completing the BASC-2 as well as a treatment acceptability questionnaire. Teachers included three general education teachers who work directly with the students and have special knowledge regarding their academic abilities. Teachers were asked to complete one questionnaire per student who received intervention. Participation was voluntary. Consent to participate was obtained from each teacher through the use of a Consent Cover Letter (Appendix D).

Materials

Materials for the current study included a 16 GB iPad4, sight words obtained from the Instant Words list (see Appendix E for the first 500 words) (Fry et al., 2000), a specifically designed iPad app, and the measures described below. The iPad app, described in detail in the next section, was designed by the primary and secondary researchers and created by an app developer. The app contains

components of effective academic interventions, including repeated opportunities to respond and corrective feedback (e.g., Belfiore et al., 1995; Burns et al., 2008; Nist & Joseph, 2008; Shapiro, 2004; Vannest et al., 2010). The app was programmed to present all three phases of the study: baseline, intervention, and maintenance. The app also collected and stored data for each participant and each phase, individually.

Through the use of this app, students can effectively and independently run their own intervention with little to no teacher assistance required. The app provides the intervention, delivers feedback, and collects data. Furthermore, the use of an iPad provides an easy to use mode of delivery. Therefore, it was hypothesized that this intervention would be well perceived by teachers because the app provides them with a research-validated intervention to supplement their instruction. Moreover, the use of the app allows teachers to preserve their instructional and preparation time as it provides them with a ready-to-go intervention that does not require additional time to prepare materials, deliver interventions, or score worksheets. Furthermore, for students receiving reading intervention, the use of this app allows the teacher to focus their instructional time and effort toward other necessary components of reading instruction, such as text-to-text connections, making inferences and predictions, and comprehension.

The Instant Words list contains 1,000 sight words rank ordered according to the most frequently used words in the English written language (Appendix E) (Fry et al., 2000). Fry (1980) notes that the list is titled “Instant” because it is impossible to achieve fluency in reading or writing unless these words are recognized “instantly.” Yet, though the Instant Words are arranged by frequency, the correlation

to difficulty is unknown. These lists were developed from a massive frequency count of 5,088,721 running words. These running words were counted from 1,045 books (fiction and nonfiction) and magazines that contained 500-word samples across 12 subject matter areas. Throughout the word count, the Instant Word list combined different graphic forms and structural variants to give one frequency for any base word while keeping track of the variant forms of endings. For example, all variant forms of the word run (e.g., runs, running) were counted in the rank order as a single word and allowed for one position of the word run. Similarly, graphic variants (e.g., RUN, Run, run) were counted in the rank order as a single word, run. This is important because 60% of the first 300 Instant Words have common variants (Fry, 1980).

The Instant Words are grouped into lists of 100 words each. Thus, the first 100 words (words 1-99) are examined to be the most frequently written (Fry et al., 2000). Ten words will be randomly selected from each 100-word list to form a group. Therefore, 10 groups of 10 words each will be constructed from each 100-word list, resulting in 100 total groups of words. The lists will be presented to participants according to their ranked frequency. Therefore, each participant will complete the 10 groups from the first 100 words before moving onto the next 10 groups from the second 100 words (words 100-199).

The lists of words will progress in this order due to the frequency with which participants are likely to encounter these high-frequency words in their natural reading environment. The first 25 words make up about one-third of all printed material, the first 100 words make up about 50% of all written material, and the

first 300 make up about 65% of all written material (Fry, 1980; Fry et al., 2000). Thus, ensuring that students can quickly and accurately recognize these words is essential.

iPad App

The components of the design and intention of the app were to provide multiple opportunities for the participant to practice reading the target words and receive feedback based on their performance in order to learn and accurately identify each target word. The app design was based on the time-delay taped-words intervention that has been shown to be effective at improving academic fluency (e.g. Freeman & McLaughlin, 1984; McCallum et al., 2004; McCallum et al., 2010; Mills, 2011; Pummel, 2011; Todd, 2010; Windingstad et al., 2009). Participants were challenged to correctly identify the target word amidst a group of distractor words within the given time interval.

Target words were presented in groups of 10. Each target word was presented at each of 3 different time-delays. First, target words were presented and followed by a 1-second time-delay. This brief time-delay was intended to prevent errors by providing the participant with the correct pronunciation of the word almost immediately (McCallum et al., 2004). Next, each word was presented and followed by a 4-second time-delay. This longer time-delay was intended to allow the participant more time to respond and to promote independence of reading. Lastly, the participant practiced each word at a 2-second time-delay. This time-delay was intended to increase automaticity. Interventions that provide students with

repeated opportunities to practice and provide corrective feedback, such as time-delay taped-words procedures, have been found to increase sight word acquisition, improve reading fluency, and minimize student errors (Belfiore et al., 1995; Nist & Joseph, 2008; Shapiro, 2004; Stevens & Schuster, 1999).

Each time a target word was presented it was paired with three distractor words. The target word and distractor words were organized in a matrix-type layout (Figure 1). Distractor words were chosen randomly from the same (100) list of Fry words. The location of the target word within the matrix was random and unpredictable to the participant. The words were black amidst a white background. This same layout was used across all phases: baseline, intervention, and maintenance. The participant's goal was to correctly read and identify the target word within the time-delay for each phase.

Four words were presented visually within the matrix for a length of 1 second to allow the participant to scan each word. The target word was then presented audibly and the time-delay began. The delay was the time that elapsed between the audible presentation of the target word and the end of the presentation when the participant was given feedback. Once the participant was presented with all four words and the audible presentation of the target word, the participant responded by touching the word they believed to be the target word. To be scored as correct the participant must have answered correctly before the time-delay elapsed.

The app provided the participant with corrective feedback at the end of each

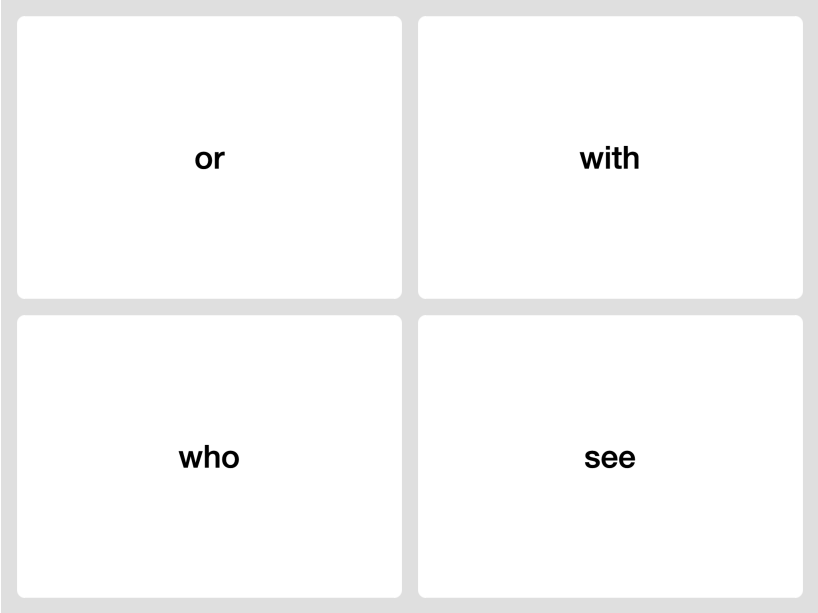

Figure 1. Matrix-Type Layout

item. If the participant did not respond and the time-delay elapsed, the color of the target word briefly changed to red to notify the participant that time-delay had elapsed (Figure 2). The target word then changed back to black and was surrounded with a green background to allow the participant to see the correct response (Figure 3).

If the participant chose an incorrect response, the text of the incorrect word changed to red and the target word appeared with a green background (Figure 4). After an incorrect response, the participant was required to touch the target word before the next item appeared. When the participant did so, they were provided with one more audible presentation of the word. This ensured that the participant attended to the item and associated the audible and visual presentations of the target word.

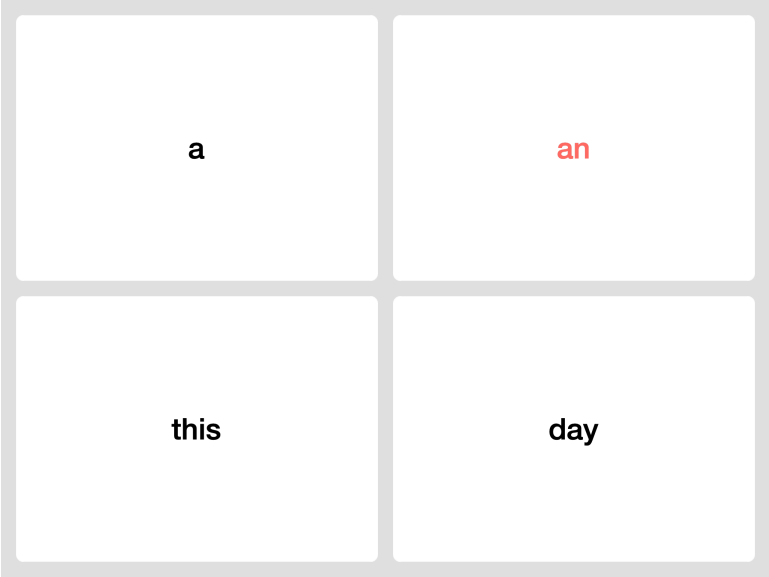

Figure 2. Elapsed Delay.

Figure 3. Corrective Feedback.

Figure 4. Incorrect Response and Corrective Feedback.

If the participant's selection was correct, it appeared in green and 1 second elapsed before the presentation of the next item. This series continued until the participant completed each time-delay for all ten target words. This was considered a complete session. The participant completed three sessions each day.

Measures

Screening

1. Dynamic Indicators of Basic Early Literacy Skills (DIBELS) benchmark assessment (Good & Kaminski, 2002; Good, Kaminski, & Dill, 2007).
    a. DIBELS Oral Reading Fluency (DORF) is a standardized set of passages and administration procedures that is individually administered as a test of accuracy and fluency with connected text. DORF is designed to

identify children who may need additional instructional support and to monitor progress toward instructional goals (Good, Kaminski, & Dill, 2002; Good et al., 2007; Shinn & Shinn, 2002).

b. DORF scores will be used to determine eligibility.

2. San Diego Quick Assessment of Reading Ability (LaPray & Ramon, 1969).
    a. The San Diego Quick Assessment is a graded word list used to determine a student's reading level, detect errors using word analysis, and is a measure of out-of-context word recognition (Diamond & Thorsnes, 2008).
    b. In a given grade level, one or fewer errors is considered the student's independent reading level, two errors is considered the student's instructional level, and three or more errors is considered the student's frustrational level.
    c. The San Diego Quick Assessment is used in reading assessment and reading intervention programs such as the CORE (Diamond & Thorsnes, 2008) and REWARDS (Archer, Gleason, & Vachon, 2014) to provide an estimate of reading level.

Dependent Variables

1. Woodcock Johnson IV Tests of Achievement (WJ IV ACH) (Schrank, Mather, & McGrew, 2014).
    a. The WJ IV ACH is a standardized assessment measure that allows for the individual assessment of academic abilities.

   b. Participants were assessed using the Reading Fluency and Reading Rate cluster tests. The Reading Fluency cluster measures aspects of reading fluency such as prosody, automaticity, and accuracy. The Reading Rate cluster provides a measure of automaticity with reading at the single-word and sentence levels (Mather & Wendling, 2014).
   c. Participants were assessed pre- and post-intervention.

2. Fry's fifth 100 Instant Words (words 400-499) (Fry et al., 2000).
   a. The fifth 100 instant words were used as preintervention, postintervention, and maintenance assessments.
   b. Participants were asked to read the fifth 100 words to the researcher before beginning to use the iPad app to practice and learn these words. Percent correct was collected prior to using the iPad app. After completing the time-delay taped-words trials of the fifth 100 words, participants were asked to read the list of words to the researcher and percent correct was collected. Percent correct was also collected 2 weeks postintervention.
3. Behavior Assessment System for Children, Second Edition (BASC-2) Teacher Rating Scales (TRS) (Reynolds & Kamphaus, 2004).
   a. The BASC-2 TRS is a behavioral assessment system designed to measure adaptive and problem behaviors in the school setting. Teachers rate behaviors on a 4-point scale that ranges from "never" to "almost always." Each participant's teacher completed the BASC-2 TRS after parental permission and participant assent were obtained.

   b. The BASC-2 was used to support inclusion criteria.

4. Behavior Intervention Rating Scale (BIRS)(Elliott & Von Brock Treuting, 1991).
   a. The BIRS was developed as a social validity measurement to assess teacher perceptions of treatment acceptability and perceived effectiveness of classroom interventions.
   b. A shortened and modified version of the BIRS was used to assess teacher and student perceptions of the intervention's acceptability and effectiveness (Appendix F & G).
   c. Teachers completed twelve items through statements that reflect Acceptability, Effectiveness, and Time. A 6-point Likert format was used with phrases ranging from *strongly agree* to *strongly disagree*.
   d. Students completed a 10-item, 6-point Likert scale to reflect treatment Acceptability, Effectiveness, and Time. Responses were averaged across participants for each item as well as each grouping.

Generalization

1. DIBELS Oral Reading Fluency Progress Monitoring Second and Third Grade Scoring Booklets (Good, Kaminski, & Dill, 2007).
   a. DIBELS progress-monitoring will be used in order to evaluate the generalization of intervention effects onto other measures of oral reading fluency.
   b. The DORF passages provide information regarding the number of

words read correctly within 1-minute from a connected text passage. During the administration of the passage, words omitted, substituted, or hesitations for more than 3 seconds are scored as incorrect. Words read correctly or self-corrected within 3 seconds are scored as accurate. The total number correct provides the oral reading fluency score (University of Oregon Center on Teaching & Learning, 2013).

c. DORF is designed to monitor progress toward instructional goals (Good et al., 2002; Good et al., 2007; Shinn & Shinn, 2002). Thus, these progress-monitoring probes will be used in order to determine each participant's current ORF at the beginning of the intervention and to assess the participant's growth after completing the intervention. Three progress-monitoring assessments will be administered prior to the start of the intervention and at the conclusion of the intervention for each participant. The median score will be collected for each assessment phase, compared, and reported as descriptive statistics.

PROCEDURES

Design

This study was conducted using a variation of an AB design. The AB design is a type of single-subject experimental design where the participant serves as his or her own control. Single-subject research design compares the participant's performance during a baseline condition with performance under a treatment condition (Horner et al., 2005). The goal of this design is to determine whether a causal relationship exists between the independent variable and the dependent variable (Horner et al., 2005; Smith, 2012). Hayes (1981) summarized that all single-subject designs are organized by core elements that can be used creatively to align with good clinical decision making and categorized into three types: within-series, between-series, and combined-series.

The current study design utilized a within-series simple phase change strategy. This strategy consists of establishing a baseline, implementing a change (intervention), and the examination of change between the conditions. Hayes (1981) notes that the effect should be replicated to increase confidence in the effect of the phase change. The phase change may be repeated in reverse order (e.g., A/B/A) and can be repeated indefinitely where each sequence forms a new completed design (e.g., A/B/A/B). The current study utilized this simple phase change, repeated three times (A/B/A/B/A/B), to systematically track intervention effects as participants

encountered new lists of words (Figure 5.).

1. *Baseline Phase A1*: 30 target words from the first 100 Instant Words.
    a. Target words were split into groups of 10 words. Each target word was paired with three distractor words (e.g., Figure 1) and presented at 2-second time-delay. Each target word was presented once for a total of 30 target word presentations.
    b. Percent accurate for each group of 10 served as the baseline data point for a total of three baseline data points for *A1*.
2. *Intervention Phase B1*: The first 100 Instant Words broken into groups of 10 words. Each target word was paired with three distractor words.
    a. Ten target words and distractors were first presented and practiced at a 1-second time-delay. Once all 10 words were presented at a 1-second time-delay, target words and distractors were presented again at a 4-second time-delay. Ten target words were then presented with distractors at a 2-second time-delay.
    b. Percent accurate on the 2-second time-delay of each group served as the dependent variable for a total of 10 data points for *B1*.
    c. Participants completed *Intervention Phase B1* when all 100 target words (10 groups of 10 words) were attempted at each time-delay (1s, 4s, 2s), and at least 80% accuracy was achieved on the 2-second delays.
3. *Baseline Phase A2*: 30 target words from the second 100 Instant Words.
    a. Grouped into three groups of 10 words. Each target word was paired

with three distractor words and presented at a 2-second time-delay. Each target word was presented once for a total of 30 word presentations.

   b. Percent accurate for each group of 10 served as a baseline data point for a total of three baseline data points for *A2*.

4. *Intervention Phase B2*: The second 100 Instant Words broken into groups of 10 words. Each target word was paired with three distractor words.
   a. Ten target words and distractors were first presented and practiced at a 1-second time-delay. Once all 10 words were presented at a 1-second time-delay, target words and distractors were presented again at a 4-second time-delay. Ten target words were then presented with distractors at a 2-second time-delay.
   b. Percent accurate on the 2-second time-delay of each group served as the dependent variable for a total of 10 data points for *B2*.
   c. Participants completed *Intervention Phase B2* when all 100 target words (10 groups of 10 words) were attempted at each time-delay (1s, 4s, 2s), and at least 80% accuracy on the 2-second delays (dependent variable) was achieved.
5. *Baseline Phase A3*: 30 target words from the third 100 Instant Words.
   a. Grouped into three groups of 10 words. Each target word was paired with three distractor words and presented at a 2-second time-delay. Each target word was presented once for a total of 30 word presentations.

   b. Percent accurate for each group of 10 served as a baseline data point for a total of three baseline data points for *A3*.

6. *Intervention Phase B3*: 300 target words from the third, fourth and fifth 100 Instant Words.
   a. Target words were broken into groups of 10 words. Each target word was paired with three distractor words. Ten target words and distractors were first presented and practiced at a 1-second time-delay. Once all 10 words were presented at a 1-second time-delay, 10 target words and distractors were presented again at a 4-second time-delay. Ten target words were then presented with distractors at a 2-second time-delay.
   b. Percent accurate on the 2-second time-delay of each group served as the dependent variable. Each participant has 30 data points for *B3*. Participants completed *Intervention Phase B3* when they finished the first 500 words.
7. *Maintenance Phase*: 90 target words (30 each from List 1, List 2, and List 3).
   a. Target words were the same words used in Baselines *A1, A2, A3*. Words were presented in groups of 10 words for a total of nine groups of 10 words each (90 word presentations. Each target word was paired with three distractor words and presented at a 2-second time-delay.
   b. Percent accurate for each group of 10 served as maintenance data points for a total of nine data points for the *Maintenance Phase*.

The timeline for the intervention portion of the study was approximately 4 weeks. Baseline (A1, A2, A3) and intervention (B1, B2, B3) sessions were completed on a Monday-through-Thursday intervention schedule. Participants used the app 4 days per week for approximately 4 weeks. Participants 1 and 2 were the first to begin the intervention, followed by Participants 3 and 4 1 day later and Participants 5 and 6 2 days later. All participants completed 17 total days of intervention, which allowed them to practice and/or learn the first 500 Instant Fry Words (Fry, 1980). The lobby page represented in Figure 6 tracked a participant's completion of the intervention. Each dot (session) represents a practice session of 10 target words presented at three different time-delays. The participant was allowed to complete up to three sessions per day, for a total of 30 target words per day. As a participant completed each session the color of the circle changed to green or red, depending on accuracy.

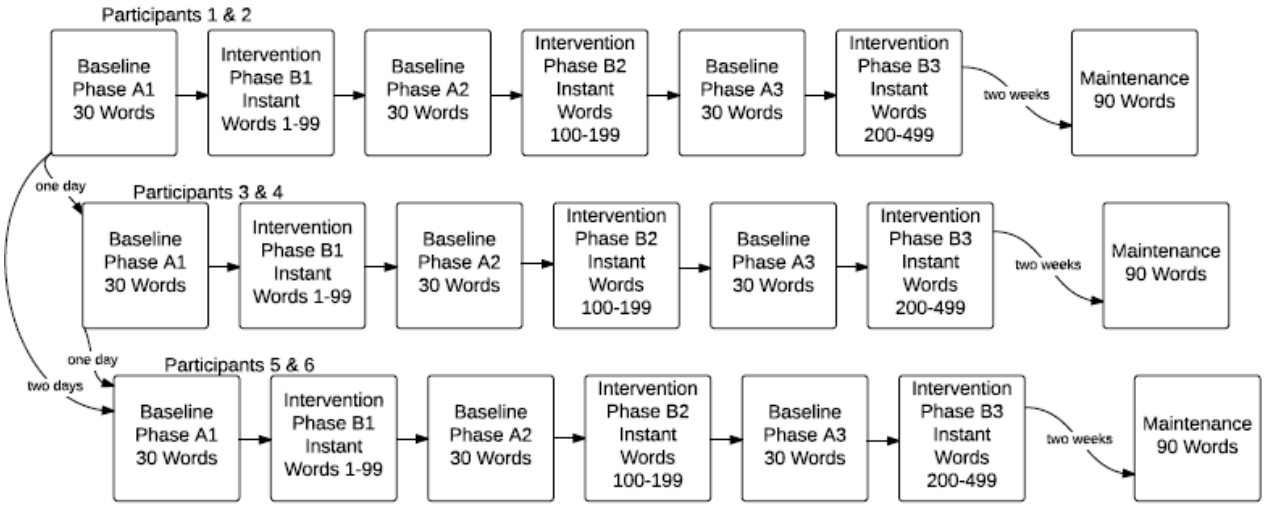

Figure 5. Intervention Progression

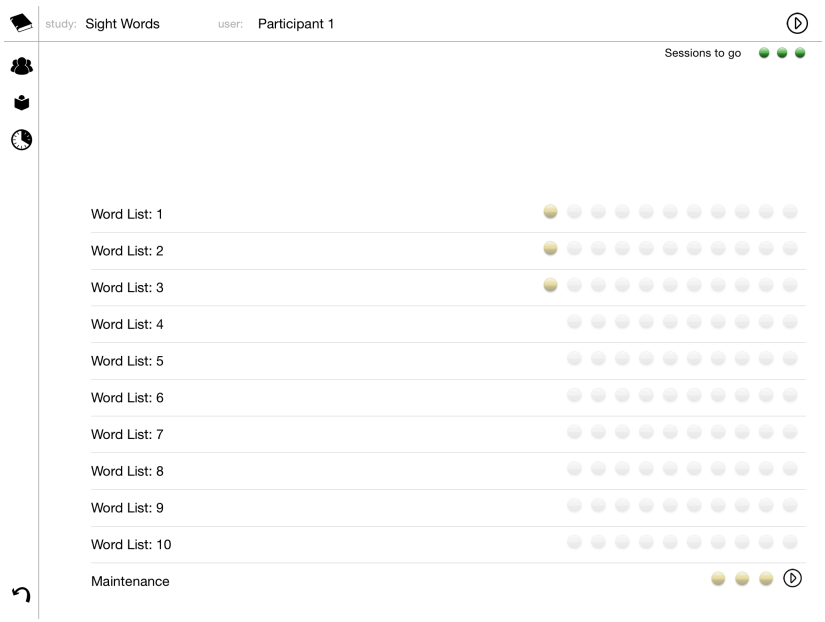

Figure 6. Lobby Page.

Intervention Procedures

Before each participant began using the app, the experimenter individually taught him/her the procedures of the intervention using a PowerPoint with screen shots from the iPad and app and pictorial examples of the intervention matrix. The participant was first taught how to locate the app on the iPad. Each participant was assigned a participant number and secret code word. The code word allowed them to verify that they chose the correct participant number. Only the experimenter and the participant knew which number and code word had been assigned to them.

To begin a session, the participant chose their participant number and pressed play. This took them to the data view screen, where they verified their secret code word. Once they acknowledged that their code word was correct, they

pressed play to go to the game-play screen. Each participant viewed this PowerPoint and was given opportunities to ask questions. The participant then demonstrated their ability to open the app, find their participant number, and verify their secret code word. Once this succession was complete, the participant could begin the intervention.

Baseline Phases: A1, A2, A3

Participants began the intervention by completing the first three baseline probes. During each baseline phase, participants were visually presented with four words: one target, three distractors (Figure 1.). The words were presented for 1 second before the participant heard the target word. Participants were then audibly presented with a target word. The participant touched the word that they believed to be the target word. To be scored as correct, the participant must have selected the target word within 2 seconds after it was audibly presented. Participants were not provided with feedback regarding the correctness of their answer during the baseline phases. Data were recorded as percent correct. Once *A1* was complete, the participant progressed to *B1*.

The three baseline probes in each phase corresponded directly to the first three intervention lists in the following phase. Therefore, the first baseline group of 10 words a participant encountered was also the same group of 10 words that the participant encountered during the first intervention session. This correspondence allows for direct inferences to be made regarding the effectiveness of the intervention. Baseline sessions were administered by the app using the same format

as intervention sessions, but did not include feedback regarding the correct or incorrect answer.

Intervention Phases: B1, B2, B3

Each participant completed three intervention sessions per day. Each session contained 10 target words. These target words were presented 3 times, once at each time-delay. This gave the participant the opportunity to practice and learn up to 30 target words per intervention session.

Parallel to each baseline probe, participants were visually presented with four words: one target, three distractors (Figure 1.). The words were presented for 1 second before the participant heard the target word. Participants were then audibly presented with a target word. The participant read the words and attempted to touch the target word before the time-delay elapsed.

Each group of words was presented 3 times at each of three different time-delays. The first was presented with a 1-second time-delay. This brief time-delay was intended to prevent errors by providing the participant with the correct pronunciation of the word almost immediately (McCallum et al., 2004). The second was presented with a 4-second time-delay. This longer time-delay was intended to allow the participant more time to respond and to promote independence of reading. Lastly, the participant completed the group at a 2-second time-delay. This time-delay was intended to increase automaticity. Interventions that provide students with repeated opportunities to practice and provide corrective feedback, such as time-delay taped-words procedures, have been found to increase sight word

acquisition, improve reading fluency, and minimize student errors (Belfiore et al., 1995; Nist & Joseph, 2008; Shapiro, 2004; Stevens & Schuster, 1999).

The order of presentation of target words was randomized on each time-delay to control for an order of learning effect. Target words were paired with three distractor words (Figure 1.). The pairing of target and distractor words was different on each presentation of a target word in order to prevent paired associations. Distractor words were chosen randomly from the respective list of 100 words from which the target words were chosen. For example, target words from Word List 1 were paired with distractor words from Word List 1.

Sessions were conducted 4 days per week, Monday through Thursday. The intervention phase was 17 sessions. This allowed the participant to learn and/or practice the first 500 Instant Fry Words (Fry, 1980). It took each participant approximately 4 calendar weeks to complete the intervention, with slight differences based on start dates and absences.

Maintenance Phase

Two weeks postintervention participants completed the maintenance phase that consisted of nine previously taught groups of words. The words used during the maintenance phase were the same as the words probed in the baseline phase and the same as the first three groups from each intervention phase. Items were presented identically to the baseline phase, without feedback or correction.

Dependent Measures

Word reading fluency served as the main dependent variable in this study. The iPad app collected data on the number of words read correctly within 2 seconds during the baseline, intervention, and maintenance phases. The mean percentage of words read correctly was compared across phases, and effect sizes were calculated in order to determine overall effectiveness of the intervention.

In addition, the percentage of the fifth 100 Instant Words (words 400-499) (Fry et al., 2000) read correctly prior to learning these words on the app was compared to the percentage read correctly at the conclusion of the intervention and 2 weeks postintervention and provided as descriptive statistics. These data provided information regarding the overall acquisition of Instant Words independent of time-delays and technology.

Intervention effects were also estimated by using DORF (Good, et al., 2007) and WJ IV ACH reading cluster tests (Schrank et al., 2014) in order to measure the amount of generalization that occurred across measures of reading fluency. The number of words read correctly (words correct per minute, WCPM) and standard scores will serve as the dependent variables for the DORF and WJ IV ACH assessments, respectively (Deno, 1985; Good et al., 2002; Good et al., 2007; Schrank et al., 2014).

Data Collection

Prior to the beginning of the intervention the experimenter will collect the following data from each participant. Participants were asked to read three DORF

progress-monitoring probes (Good et al., 2007) and were administered the WJ IV ACH Reading Fluency and Reading Rate cluster subtests (Schrank et al., 2014). Baseline data were collected by the iPad app. Participants were asked to read the fifth 100 Instant Words (words 400-499) (Fry et al., 2000) to the researcher before beginning practice of these words on the iPad.

The DORF was administered by the researcher and followed the directions as outlined in the *DIBELS Oral Reading Fluency Progress Monitoring Scoring Booklet* for repeated reading (Good et al., 2007). Three probes were administered at each assessment phase. Scores were recorded as WCPM. The median scores were used for data analysis.

The researcher administered the WJ IV ACH Reading Fluency and Reading Rate cluster subtests (Schrank et al., 2014). The administration of these subtests is standardized and the researcher is trained to adhere to the standardization procedures. Standard scores are reported.

A total of 9 baseline data points were collected: 3 baseline data points for each baseline phase (A1, A2, A3). A data point represents the percentage of correctly read words for each trial. A trial consisted of 10 words, each recorded with a 2-second time-delay. Thus, target words read and identified correctly within 2 seconds were scored as correct.

Participants read the fifth 100 Instant Words (words 400-499) to the researcher before beginning to use the iPad app to learn and practice these words. Words read correctly and incorrectly were marked. Participants were not timed, but if the participant took longer than 10 seconds to read a word, the researcher said,

"try the next one" and marked that word as incorrect. Feedback regarding the correctness of the read word was not given; neither was correction for incorrectly read words. The percentage of accurately read words was calculated.

During the intervention phase, the percentage of correctly read words on the 2-second time-delay trials was collected and served as the dependent variable to be used for data analysis. Participants first practiced each of 10 words at a 2-second and then 4-second time-delay before completing the 2-second time-delay. The app collected data for the 2-second time-delay. Participants must have selected the target word within the 2-second time-delay to be scored as correct. Data were recorded as number correct and converted to percent correct.

The 2-second time-delay is the most accurate measure of oral reading fluency since it accounts for both accuracy and rate. Reading fluency is defined as the combination of accuracy and rate of reading (Hasbrouck & Tindal, 1992; Hasbrouck & Tindal, 2006; Rathvon, 2008). Participants completed 17 days of intervention, which allowed them to practice the first 500 Instant Words (Appendix E) (Fry et al., 2000). The intervention ran for approximately 4 weeks. Therefore, each participant had 50 data points for the intervention phase. Intervention phases B1 and B2 each contained 10 data points, while intervention phase B3 had 30 data points.

At the conclusion of the intervention the experimenter collected data similar to the data collected prior to the start of the intervention. Participants were asked to read three DORF progress-monitoring probes (Good et al., 2007), were administered the WJ IV ACH Reading Fluency and Reading Rate cluster subtests

(Schrank et al., 2014), and read the fifth 100 Instant Words (Appendix E) (Fry et al., 2000).

Maintenance data were collected 2 weeks postintervention for each participant. Maintenance trials consisted of the baseline lists that were previously probed during the baseline phase and taught during the intervention. Therefore, each participant has 9 maintenance data points. Maintenance lists were administered by the iPad app in the same fashion as baseline was collected, at a 2-second time-delay. The dependent variable is the percent correct.

Supplementary to data analyzing the effectiveness of the intervention are data that provide evidence that consumers find the intervention acceptable, effective, and worthy of the time allocated to its completion. Elliott and Von Brock Treuting (1991) suggested that methods are needed to assess consumer attitudes toward differing interventions in order to fully assess the utility and usability of an intervention. To do so, the researchers developed an instrument called the Behavior Intervention Rating Scale (BIRS). The BIRS consists of 24 items rated along a 6-point Likert format that includes ranges of statements from *strongly disagree* to *strongly agree*. The BIRS measures teachers' perceptions of treatment acceptability and treatment effectiveness across three factors: Acceptability, Effectiveness, and Time. Previous research has found that teachers' acceptability ratings are influenced by the severity of the student's difficulties, the type of intervention, the perceived effectiveness of the intervention, and the amount of time the teacher is required to allocate to the problem and intervention (as cited in Elliott & Von Brock Treuting, 1991).

For the current study, treatment acceptability data were collected from the participants and teachers. Shortened and modified versions of the BIRS (Elliott & Von Brock Treuting, 1991) were created by the researcher and used to assess teacher and student perceptions of the intervention's acceptability and effectiveness. Data were collected using the Intervention Acceptability – Teacher Rating Form (Appendix F) and the Intervention Acceptability – Student Rating Form (Appendix G). The teacher rating form is a 12 item, 6-point Likert scale. Six of the twelve items assess Acceptability, four items assess Effectiveness, and two items assess Time. The student rating form is a 10-item, 6-point Likert scale. Five of the ten items assess Acceptability, three items assess Effectiveness, and two items assess Time.

Treatment acceptability data were collected at the conclusion of the study. The teacher rating form was distributed to teachers via email using a Google document. This allowed teachers to complete the rating form anonymously. The questionnaire asked student specific questions, such as: "This intervention produced lasting improvements to the student's sight word reading." Thus, teachers were asked to complete one questionnaire per participating student. Students completed the rating form by accessing the Google document from the researcher's iPad after the completion of the maintenance phase. Students' answers were anonymous to the researcher, who did not analyze the data until all students had input their ratings. Students were asked to read the statements aloud to ensure accuracy of reading, but the researcher did not monitor responses.

Reliability data were collected by the primary researcher and analyzed by a

research assistant. The primary researcher videotaped one third of all sessions for each participant. A research assistant viewed all videotapes and coded each video for reliability using the Reliability Checklist (Appendix H).

Data Analysis

Do students at risk for reading difficulties become more accurate at recognizing Instant Words through the use of this intervention? Is accuracy maintained at follow-up? The number of words read correctly within the 2-second time-delay was collected and recorded for baseline, intervention, and maintenance trials. Words read correctly were converted into percent correct. Mean percent correct on baseline measures will be compared to mean percent correct on intervention measures and intervention measures will be compared to mean percent correct on maintenance measures. Data are presented within a graph for overall visual analysis.

Effect sizes were calculated by combining the baseline phases (AAA) in comparison to the combination of intervention phases (BBB) using Tau-U. Tau-U is a set of indices that combine Phase AB nonoverlap with Phase B trend and controls for positive baseline trend (Parker, Vannest, Davis, & Sauber, 2011). Tau-U is calculated based on the percentage of nonoverlap minus overlap and controlled for positive baseline trend. Nonoverlap is based on pairwise comparisons, where each comparison is determined to be positive, negative, or tie. Tau-U is one of the only methods in single-case research that controls for positive baseline trend. Some advantages of Tau-U include conservative trend control and greater statistical

power than other single-case research methods (Parker, Vannest, & Davis, 2011).

Was an increase in word reading observed? Prior to beginning practice of these words on the iPad, after concluding intervention, and 2 weeks postintervention, each participant was asked to read the fifth 100 Instant Words (words 400-499) (Fry et al., 2000) to the researcher. The percentage of accurately read words was calculated for each assessment phase. Percent correct prior to the beginning of the intervention will be compared to percent correct at the conclusion of the intervention and postintervention and reported as descriptive statistics for each participant as well as averaged across participants.

Did intervention effects generalize across reading fluency measures? Preintervention and postintervention data from DORF measures were compared. Three probes were administered at each assessment phase. Scores were recorded as WCPM. The median scores were used for data analysis and compared to assess whether the time-delay taped-words intervention generalized to an increase in the participant's oral reading fluency.

Preintervention and postintervention scores from the WJ IV ACH (Schrank et al., 2014) are reported. The Reading Fluency cluster measures aspects of reading fluency such as prosody, automaticity, and accuracy. The Reading Rate cluster provides a measure of automaticity with reading at the single-word and sentence levels (Schrank et al., 2014). Standard scores will be reported as descriptive statistics. Inferences may be made regarding the effect of the time-delay taped-intervention as assessed by a standardized measure of academic achievement.

Do teachers find this intervention acceptable, effective, and time-efficient? Do

students find this intervention acceptable, effective, and time-efficient? Treatment acceptability data were collected from the participants and teachers at the conclusion of the intervention. Shortened and modified versions of the BIRS (Elliott & Von Brock Treuting, 1991) were used to assess teacher and student perceptions of the intervention's acceptability and effectiveness (Appendix F & G). Teachers completed twelve items through statements that reflect Acceptability, Effectiveness, and Time. A 6-point Likert format was used with phrases ranging from *strongly agree* to *strongly disagree*. For each item, responses were averaged and the mean quantitative variable and closest qualitative description is provided. Responses were also averaged to reflect the average group score for Acceptability, Effectiveness, and Time. Students completed a 10-item, 6-point Likert scale to reflect treatment Acceptability, Effectiveness, and Time. Responses were averaged across participants for each item as well as each grouping.

Reliability data were collected. The researcher videotaped one third of all sessions. A research assistant viewed and coded each video for reliability using the Reliability Checklist (Appendix H). Results are reported as overall percent of procedures completed accurately. Additionally, because this intervention using the iPad app was designed to be completed with fidelity by students themselves, reliability data focus specifically on the participant's ability to complete the intervention procedures independently without prompting from the researcher. These data are reported as descriptive statistics.

RESULTS

The purpose of the current study was to empirically evaluate the effectiveness of a specifically designed app to administer the time-delay taped-words intervention. The app was designed by the researcher to contain components of effective academic interventions, such as repeated opportunities to respond and immediate and corrective feedback. The intervention utilized mobile technology, an iPad4, as the mode of delivery and data collection. This study was conducted using a variation of an AB design that utilized a within-series simple phase change strategy with replicated AB phases. Measures were also used to determine the effectiveness of the app on generalization of reading ability as well as to measure teacher and student acceptability. The following research questions were examined.

Analysis by Question

Six research questions were formulated to assess the effectiveness, generalizability, and acceptability of the intervention. The following information addresses each research question individually. Data and graphic representations are provided where appropriate.

Do students at risk for reading difficulties become more accurate at recognizing Instant Words through the use of this intervention? This single-subject research study was conducted using a variation of an AB design. A within-series

simple-phase-change strategy was utilized. This strategy consists of establishing a baseline, implementing a change (intervention), and the examination of change between the conditions. Hayes (1981) notes that the effect should be replicated to increase confidence in the effect of the phase change. The phase change may be repeated in reverse order (e.g., A/B/A) and can be repeated indefinitely where each sequence forms a new completed design (e.g., A/B/A/B). The current study utilized this simple phase change, repeated three times (A/B/A/B/A/B) to systematically track intervention effects as participants encountered new lists of words.

During each phase of A, participants completed three baseline lists. Baseline lists were derived from the respective grouping of 100 words. Thus, baseline A1 utilized three lists of 10 words each from the first 100 Instant Words (words 1-99). Baseline A2 was comprised of three lists of 10 words each from the second 100 Instant Words (words 100-199) and A3 was comprised of three lists of 10 words each from the third 100 Instant Words (words 200-299). The Instant Words list contains 1,000 sight words rank-ordered according to the most frequently used words in the English written language. The first 25 words make up about one third of all printed material, the first 100 words make up about 50% of all written material, and the first 300 make up about 65% of all written material (Fry, 1980; Fry et al., 2000).

The dependent variable was the percentage of words recognized accurately within 2 seconds. Baseline results indicated that participants were already highly familiar with recognizing these high-frequency words (*m* = 95.3%). Thus, their use of the iPad app for these words may be better described as practice of previously

mastered words. Therefore and unfortunately, the effectiveness of this intervention was not best measured using these lists as a baseline measure (Table 1.). Nonetheless, effect sizes were calculated for each participant and graphs are available for visual analysis.

The reader is pointed to Research Questions 3 and 4, which provide additional measures of intervention effectiveness and generalizability. Participants were probed to read the fifth 100 Instant Words (words 400-499) (Fry et al., 2000) before beginning instruction on these words. Mean percent preintervention is compared to mean percent postintervention, which led to gains for all participants

Table 1.

Mean Percent Accurate by Phase

Participant	Baseline	Intervention	Maintenance
1	91.1%	92.8%	93.3%
2	98.8%	94%	100%
3	96.6%	95.4%	93.3%
4	95.5%	97.6%	95.5%
5	94.4%	92.6%	92.2%
6	95.5%	93.4%	94.4%
Mean Percent Accurate Across Participants	95.3%	94.3%	94.7%

in reading and recognizing these words. Research Question 4 examined whether using the iPad app generalized to gains in oral reading fluency as assessed by DORF (Good & Kaminski, 2002; Good, et al., 2007).

Tau-U indices were calculated for all participants using the Tau-U calculator (Vannest, Parker, & Gonen, 2011). Tau-U measures data nonoverlap between two phases while controlling for positive baseline trend. Tau can be interpreted as the percent of data that improve over time. The mean percent correct for each grouping of 100 words was used to calculate Tau-U. For example, A1 baseline data probes contained words from the first 100 Instant Words (Fry, et al., 2000). Each participant completed three baseline probes in A1. The average percent accurate for this phase was used as one baseline data point. Average percent correct for A2 and A3 were used as the additional baseline data points in Tau-U for each participant. Throughout the intervention phases, participants practiced and learned words from the first 500 Instant Words. Mean percent accurate was obtained for each grouping of the 100 words learned and used as the intervention data points (n=5) in calculating Tau-U.

Participant 1 was a seven-year-old girl. She earned mean percent corrects of 87%, 93%, and 93% in baseline phases. She earned mean percent corrects of 88%, 90%, 94%, 95%, and 97% in intervention phases. Using the Tau-U calculator (Vannest et al., 2011), the percent of data showing improvement between phases was 46.6% for Participant 1. Therefore, from phase A to phase B, data showed a 46.6% improvement trend (p = 0.14). Controlling for baseline improvement trend, the overall improvement was more conservatively measured at 33.3% (p = 0.29) of

data showing improvement. Percent correct across phases is presented in Figure 7.

Participant 2 is an eight-year-old boy. He earned mean percent corrects of 96%, 100%, and 100% in baseline phases. He earned mean percent corrects of 95%, 93%, 92%, 96%, and 94% in intervention phases. Using the Tau-U calculator (Vannest et al., 2011), the percent of data showing improvement between phases was -93%. This indicates that 93% of pairs either tied or did not improve from baseline (p = 0.03). These results show that Participant 2 was already proficient at reading the first 300 Instant Words (Fry et al., 2000) and therefore had little room to grow. This decrease was measured to be statistically significant, however, his percentages remained above 90% correct which was considered to be within the range of mastery. Percent correct across phases is presented in Figure 8.

To interpret these scores it is helpful to calculate Tau-U comparing maintenance to baseline, considering both were administered in the same manner as the baseline phase. Participant 2 earned mean percent corrects of 100% across the maintenance phase. Therefore, Tau-U calculation indicates that the percent of data showing improvement between phases was 11.1% after controlling for baseline trend. Although this change was not statistically significant (p = 0.76), it suggests that the Participant continued to demonstrate accurate recognition of the words and that the measured decrease in recognition accuracy may be better explained by another factor(s), such as iPad operation or behavioral characteristics. A few possible considerations are presented.

The participant demonstrated his mastery in recognizing these words during the baseline phase. Therefore, the observed negative relationship in nonoverlap

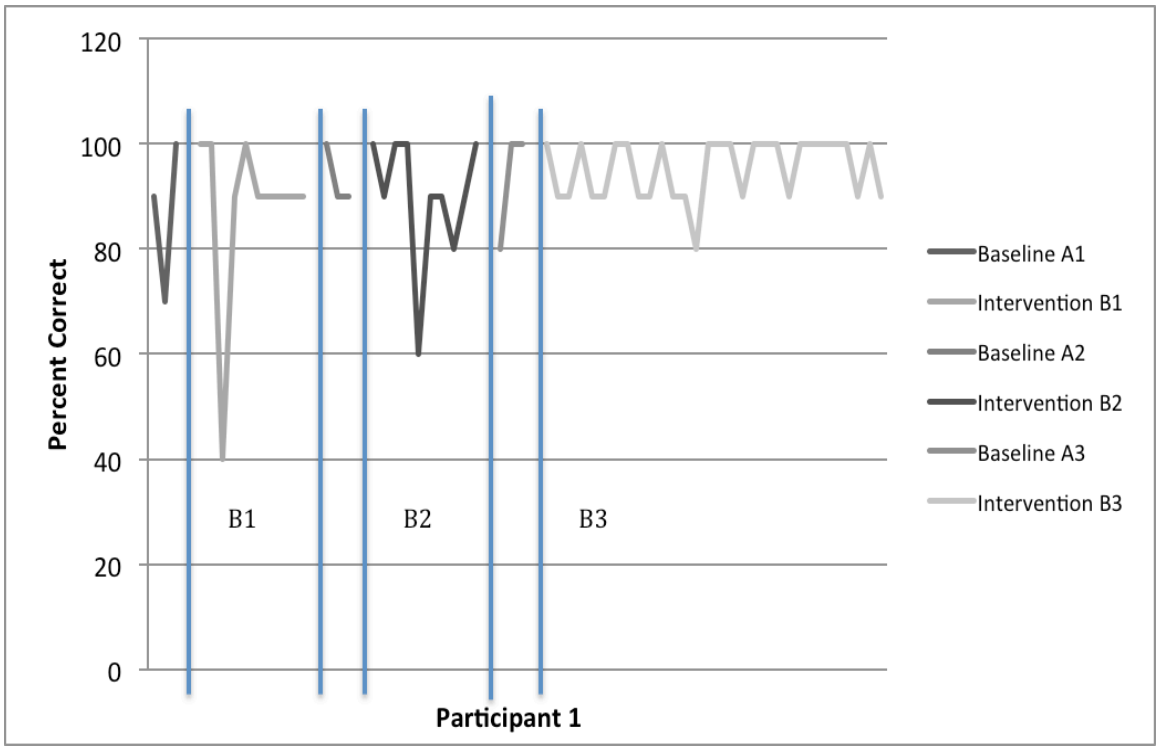

Figure 7. Participant 1.

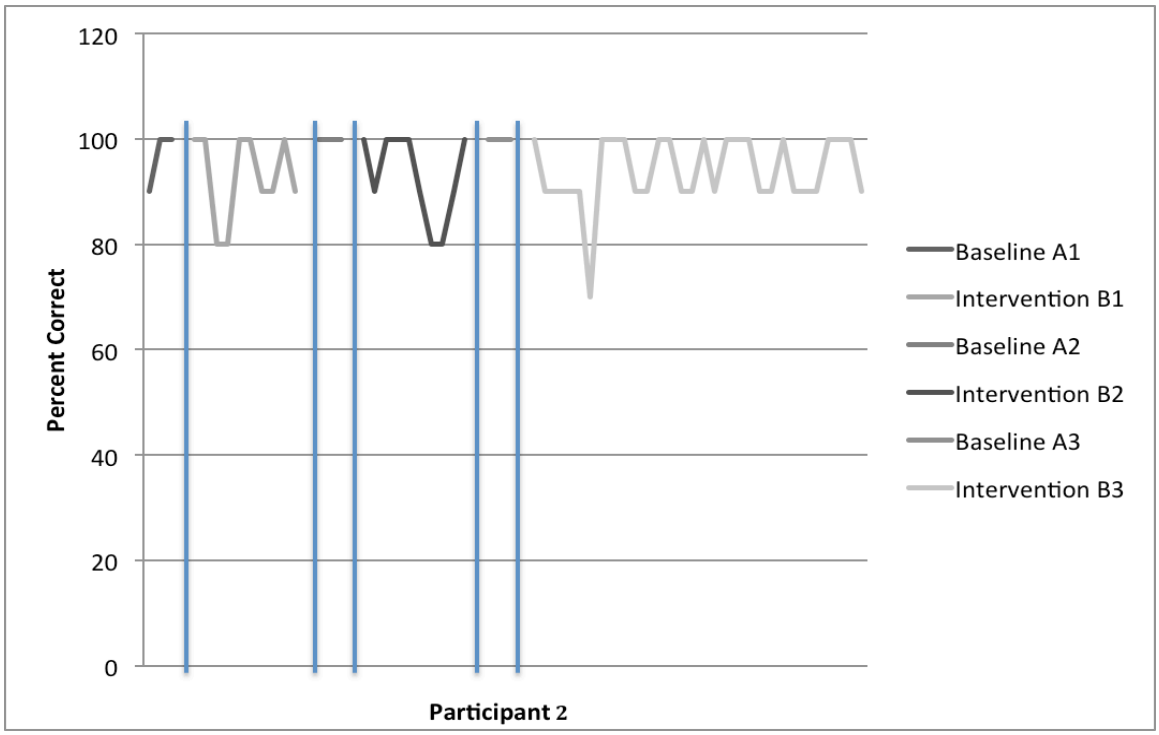

Figure 8. Participant 2.

may have occurred due to lack of interest or drive because he already knew the material. Additionally, this participant was observed to struggle with hyperactivity and impulsivity. The hyperactivity subscale on his BASC-2 confirmed this observation (T-score = 71), but he was not excluded from the study because inclusion criteria relied on composite scores, which were not clinically significant. For example, the participant enjoyed interacting in a silly manner with the iPad. Before an item was presented the participant would look away from the iPad and wait for the app to state the target word. He would then look at the choices and attempt to choose the word as quickly as possible. At times, this behavior resulted in incorrect responses as well as prompting from the researcher.

In addition, the participant also appeared to struggle to adapt to setbacks. His Adaptability subscale score fell within the At-Risk range (T = 31). For example, when working through the 1-second time-delay, the participant often knew the correct word, but struggled to touch the iPad carefully or fast enough for the iPad to register his response before marking it incorrect. Although data were not collected on this time-delay, the participant often groaned and became visibly upset when he tied the iPad and received feedback. This frustration appeared to affect his motivation on subsequent time-delays. On occasion, other participants also struggled to beat the iPad on the 1-second interval, reflecting a difficulty to physically respond fast enough, however, his response to the feedback provided was unique. For this reason, future replications of this intervention using an iPad app should consider lengthening this interval by a half- to 1 second.

Participant 3 is a seven-year-old girl. She earned mean percent corrects of

96% in all baseline phases and mean percent corrects of 98%, 93%, 95%, 94%, and 97% in intervention phases. Using the Tau-U calculator (Vannest et al., 2011), data show a decrease in trend of 20% ($p = 0.53$) between phases, however, this change was not statistically significant. Visual analysis of her graph in Figure 9 shows that she achieved mastery on all groups of words except one.

Participant 4 is an eight-year-old boy. He was observed by the researcher to be even-tempered, sustain adequate attention, and respond similarly to successes and setbacks. He earned mean percent corrects of 96%, 96%, and 93% in baseline phases and 98%, 96%, 98%, 99%, and 97% in intervention phases. Using the Tau-U calculator (Vannest et al., 2011), the percent of data showing improvement between phases was 86.6% for Participant 4. This trend was statistically significant ($p < 0.01$). Percent correct across phases is presented in Figure 10.

Participant 5 turned eight years old during the research study. He earned mean percent corrects of 93%, 96%, and 93% in all baseline phases and mean percent corrects of 90%, 96%, 91%, 93%, and 93% in intervention phases. Using the Tau-U calculator (Vannest et al., 2011), data show a decrease in trend of 40% ($p = 0.21$) between phases, however, this change was not statistically significant. Visual analysis of his graph in provided in Figure 11. It shows that he achieved mastery on all groups of words except two.

Participant 6 is an eight-year-old boy. During the time of the research study, his classroom teacher also referred for a special education evaluation by his classroom teacher. Results of that evaluation indicated that he did not qualify as a student with a learning disability. In the current study he earned mean percent

corrects of 96%, 100%, and 90% in baseline phases and 93%, 98%, 92%, 93%, and 91% in intervention phases. Using the Tau-U calculator (Vannest et al., 2011), data show a decrease in trend of 20% between phases, however, this change was not statistically significant (p = 0.53). Visual analysis of his graph is provided in Figure 12. It shows that he achieved mastery on all groups of words except one.

It was hypothesized that participants would become more accurate at recognizing Instant Words through the use of this intervention. Unfortunately, current data do not support this hypothesis. Four of six participants demonstrated insignificant changes in trend, one participant showed a statistically significant decrease, and one student demonstrated a statistically significant increase in trend. Future research replicating the effectiveness of this intervention should utilize different baseline measurements, younger students, or a different design such as a multiple-baseline design.

Is accuracy maintained at follow-up? The average percent correct on maintenance measures is presented in Table 1. Visual analyses of these results indicated that participants' average percent accurate from the intervention to maintenance phase remained relatively stable and suggests that accuracy was maintained at follow-up. Tau-U indices, comparing the intervention phases to maintenance phases, were calculated for all participants. A statistically significant change in trend was observed for Participant 2. Participant 2 received a Tau-U index of 1. This indicates that 100% of data showed an improvement from the intervention phase to the maintenance phase. This variability was discussed above. Tau-U indices for all other participants were not statistically significant, which

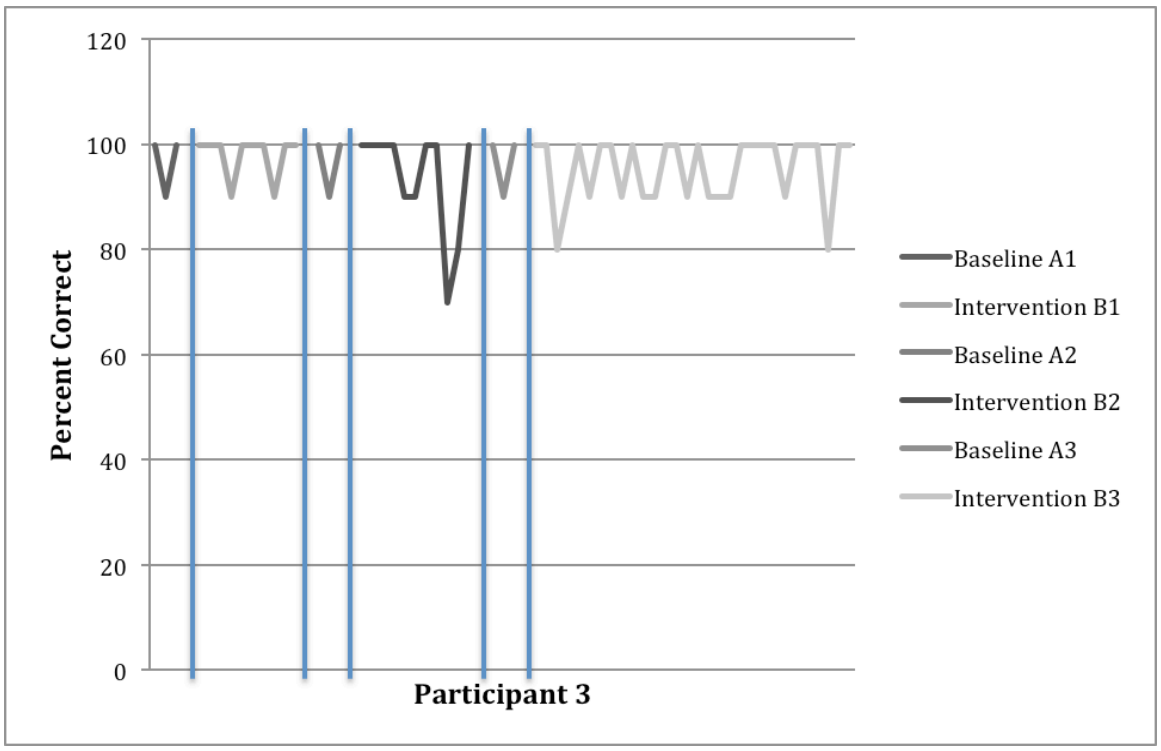

Figure 9. Participant 3.

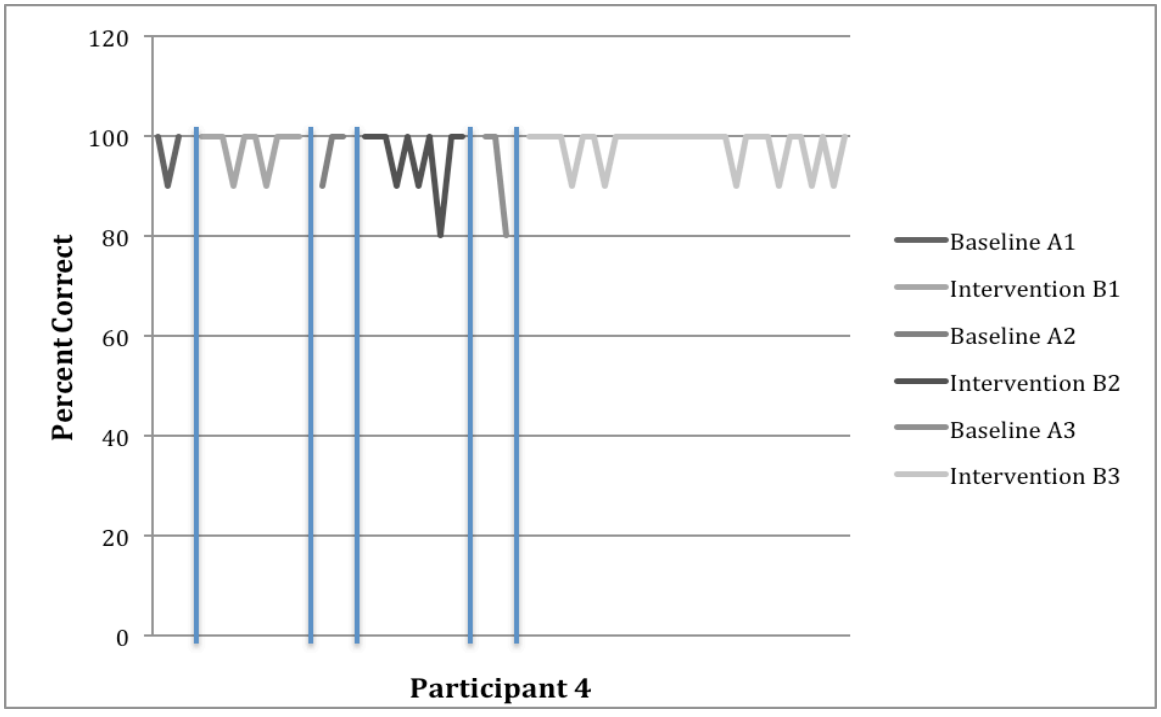

Figure 10. Participant 4.

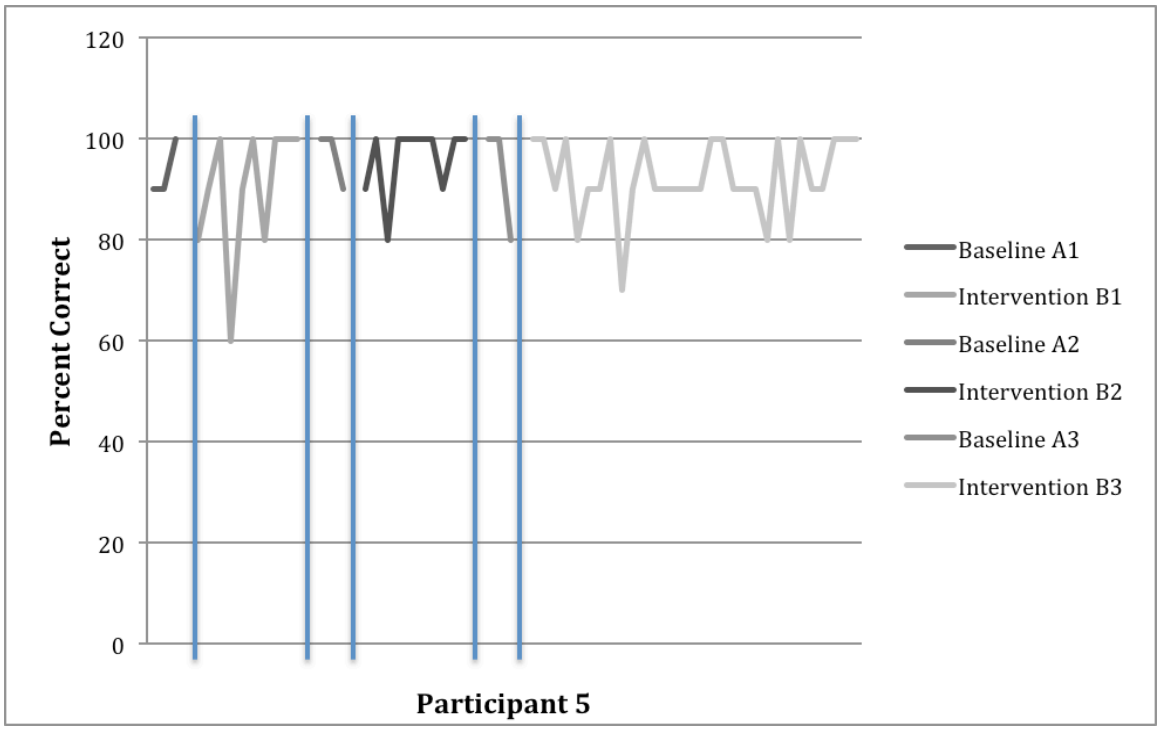

Figure 11. Participant 5.

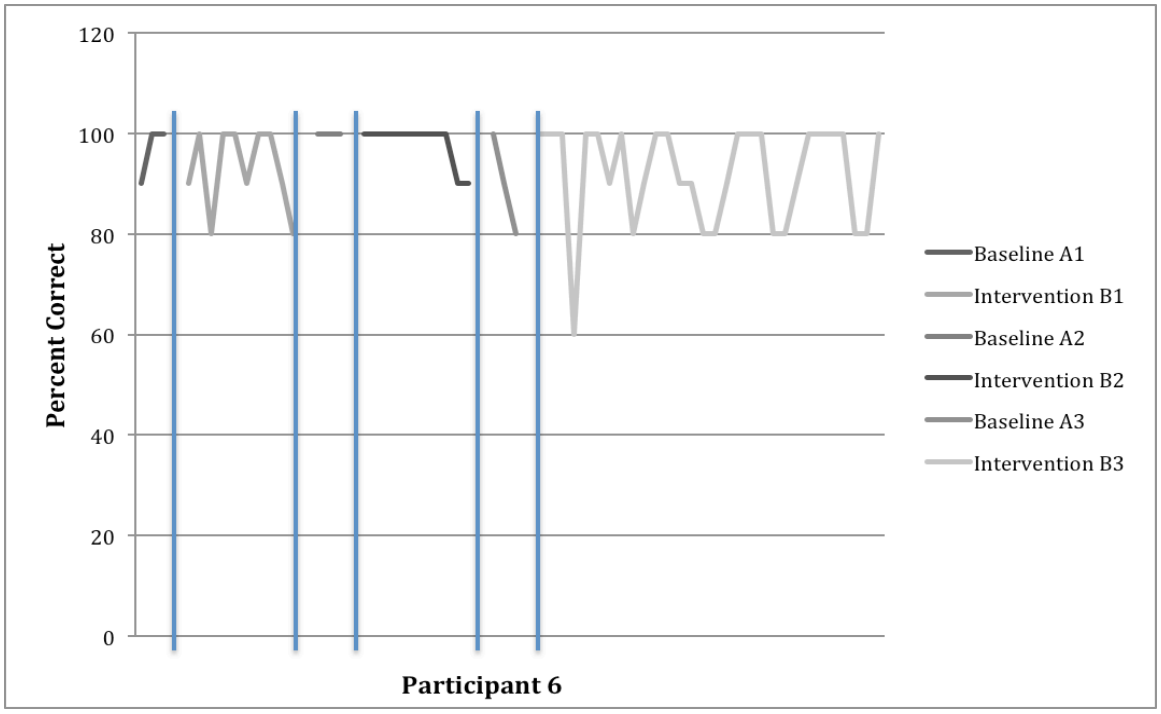

Figure 12. Participant 6.

indicates that their percent accuracy remained stable between the intervention phase and maintenance phase. Therefore, results show that all participants' accuracy was either maintained or increased from intervention to maintenance.

Was an increase in Instant Word reading observed? Participants were asked to read the fifth 100 Instant Words (words 400-499) (Fry et al., 2000) before beginning to use the iPad app to practice and learn these words, after the intervention, and at 2 weeks postintervention. Words were presented in list format with four columns of 25 words each. Participants were asked to read the words to the researcher. If the participant didn't know a word they were encouraged to give it a try and then told to move onto the next word. Participants were not timed, nor were they provided with feedback at any assessment period. Percent correct was recorded at each assessment interval. Data are represented in Figure 13.

Data showed that all participants made gains in reading the fifth 100 Instant Words (words 400-499) (Fry et al., 2000) after using the iPad app. Prior to using the iPad app to practice these words, participants knew, on average, 74.2% of the words. After using the time-delay taped-words iPad app participants could read 91.8% of the words postintervention and 94% of the words at maintenance, on average. Therefore, through the use of the iPad app, participants could read an average of 18-20% more words.

These results are even more impressive when the efficiency of this intervention is considered. Each session consisted of the participant practicing 30 Instant Words. Therefore, each participant practiced these 100 words in just over 3 days. Furthermore, each list took less than 3 minutes to complete. Therefore, in less

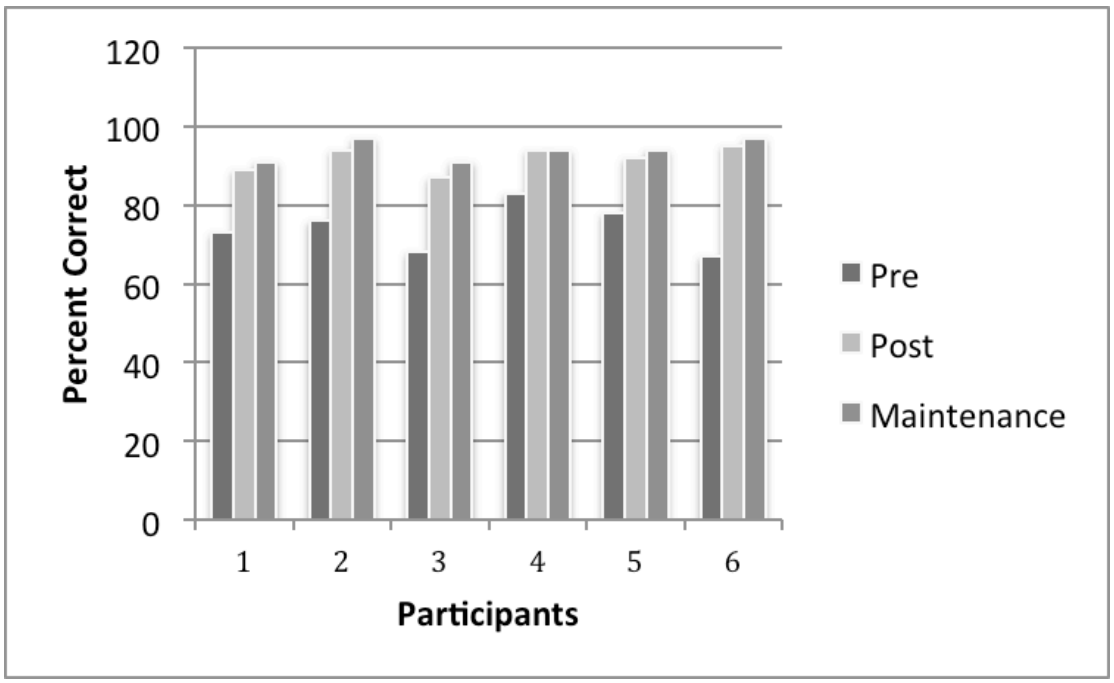

Figure 13. Percentage of Instant Words Read Correctly.

than 30 minutes of instructional time participants learned between 11 and 30 new words and maintained these gains for at least 2 weeks. The rapidity of this increase in acquired words lends support to the internal validity of the intervention. Threats to internal validity arise when alternative interpretations of the variable responsible for change, other than the treatment, exist (Kazdin, 1981).

Did intervention effects generalize across reading fluency measures?

According to Stokes and Baer (1977), generalization is the "occurrence of relevant behavior under different, nontraining conditions" (p. 10). The current study utilized a time-delay taped-words intervention implemented by an iPad app to increase second-grade students' Instant Word recognition. This intervention taught Instant Words at the single-word level. DORF measures (Good & Kaminski, 2002; Good et al., 2007) assess reading fluency through connected text passages. Thus, the current

study procedures most closely aligned with the generalization category of *Train and Hope*. This category of generalization describes research techniques that welcome the presence of generalization but do not necessarily employ techniques that train participants to generalize to other settings, responses, experimenters, or time (Stokes & Baer, 1977).

Reading fluency measures such as DORF are effective at identifying students who have difficulty learning to read as well as to assess the effectiveness of interventions designed to promote reading (Schilling et al., 2007). DORF data were collected prior to baseline, at the end of the intervention, and 2 weeks postintervention. At each of these phases, the participant was asked to read three oral reading fluency probes. The participant had 1-minute to read each passage and the number of words correct per minute (WCPM) was calculated. The median WCPM from each phase is reported and represented in Figure 14.

Prior to the baseline phase, Participant 1 read 74 WCPM (median). At the end of the intervention, her median WCPM increased to 103. Two weeks postintervention her median score remained relatively stable at 97 WCPM. Therefore, Participant 1 experienced an average increase of 26 WCPM as a result of the time-delay taped-words iPad app.

Participant 2 read 61 WCPM prior to beginning baseline. After the intervention, his median WCPM increased to 93, the highest baseline to intervention increase observed. Two weeks postintervention his median score dropped to 84 WCPM. The reason for this drop is unknown, but could be due to any number of factors related or unrelated to the intervention. Nonetheless, his maintenance score

remained 23 WCPM higher than his baseline WCPM. This increase is commensurate with the average gains made by other participants.

Participant 3 read 47 WCPM on the baseline measure. Her scored increased to 73 WCPM after the intervention was completed. Her DORF score remained stable 2 weeks postintervention at 74 WCPM. Thus, Participant 3 also experienced an increase of 26 WCPM as a result of the intervention.

Participant 4 read 77 WCPM prior to beginning baseline. His score increased to a median 105 WCPM after the intervention and stayed stable at 103 WCPM 2 weeks postintervention. Participant 4's average increase was similar to other participants at 27 WCPM.

Participant 5 read 80 WCPM prior to beginning baseline. His score increased to 88 WCPM after the intervention and to 90 WCPM 2 weeks postintervention. This participant had the most modest generalization score increase, though it was relatively stable as measured 2 weeks post.

Participant 6 read 62 WCPM on the baseline measure. His score increased to 74 WCPM at the end of the intervention and continued to increase to 83 WCPM 2 weeks postintervention. This sizeable increase from intervention to maintenance was unique compared to all other participants. The reason for this is impossible to determine, but may be due to one or a number of possible factors. For example, it may be a reflection of latent intervention effects or due to external factors other than the intervention or just attributable to testing performance on the intervention probes. Regardless, this participant continued to make gains postintervention.

Overall, the average increase in WCPM from baseline to intervention was

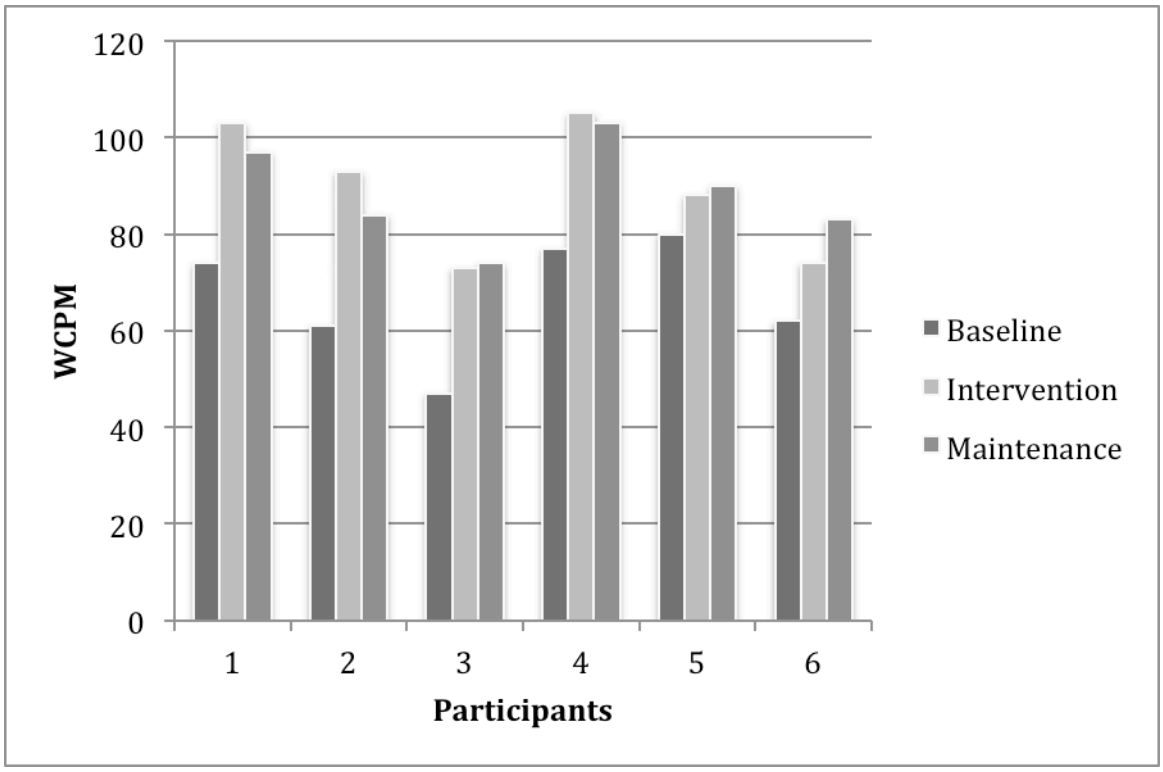

Figure 14. DORF Median Words Correct Per Minute by Phase

22.5 WCPM. This increase remained relatively stable across participants, as the average increase from baseline to maintenance was 21.6 WCPM. These data support the hypothesis that the time-delay taped-words intervention using the iPad app would be effective at increasing students' oral reading fluency and generalize to measures of connected text. This finding is impressive, given that this intervention did not specifically train participants to read words in connected text.

Additionally, the generalization probes contained new words that were not taught during the intervention. Stokes and Baer (1977) noted that studies like this "have considerable importance, for they begin to document the extent and limits of generalization of particular operant intervention techniques. While not being

examples of the programming of generalization, they are a sound first step in any serious analysis of generalization" (p. 11). These findings replicate past research using technology to implement the time-delay taped-words intervention (Pummel, 2011). Furthermore, the majority of participants' scores from intervention to maintenance remained relatively stable, which provides increased confidence in the internal validity of the intervention app. Had the increase in scores been attributable to another factor, scores likely would have continued to increase.

Reading fluency, the ability to quickly and accurately read words, has implications for reading comprehension. Research states that the rapid reading of high-frequency words and decodable words is critical for reading comprehension (Chard et al., 2009; Kim & Wagner, 2015; Rasinski, 2000; Shapiro, 2004; The University of Texas Center for Reading and Language Arts, 2004). The current study demonstrated gains in fluency for all participants on the DORF progress-monitoring probes. Therefore, in addition to gains in fluency, it is also possible that students' experienced gains in reading comprehension as well.

Participants were also administered clusters from the WJ IV ACH (Schrank et al., 2014). Clusters included Reading Fluency and Reading Rate. The Reading Fluency cluster measures aspects of reading fluency, including prosody, automaticity, and accuracy of reading using subtests that include connected text passages and sentences. The Reading Rate cluster measures automaticity at the single-word and sentence levels (Mather & Wendling, 2014). Pre- and post-intervention standard scores for each participant are listed in Table 2. Standard scores have a mean of 100 and a standard deviation of 15. Results indicated that on

this standardized measure of achievement, all participants performed within the average range before and after the intervention. Fifty percent of participants had slight increases in their reading fluency and reading rate standard scores. One participant's reading fluency score and two participants' reading rate scores stayed consistent. Two participant's reading fluency scores decreased by 1 standard point and one participant's reading rate score decreased by 3 standard points.

Do teachers find this intervention acceptable, effective, and time-efficient? Three teachers participated in rating the acceptability of this intervention. Teachers completed one rating form for each student that participated in the intervention using the Intervention Acceptability – Teacher Rating Form, a shortened and modified version of the BIRS (Elliott & Von Brock Treuting, 1991) created by the

Table 2.

Woodcock Johnson Tests of Achievement Standard Scores

	Reading Fluency		Reading Rate	
Participant	Pre-test	Post-test	Pre-test	Post-test
1	97	96	93	90
2	96	96	93	96
3	90	92	87	90
4	96	95	90	90
5	97	98	93	95
6	94	95	91	91

researcher. Twelve statements were used to assess acceptability (*n*=6), effectiveness (*n*=4), and time (*n*=2). Responses were rated on a 6-point Likert-type scale. Qualitative phrases ranged from Strongly Disagree (1), Disagree (2), Slightly Disagree (3), Slightly Agree (4), Agree (5), and Strongly Agree (6).

The average rating for each statement is reported in Table 3. Ratings were also averaged based on qualitative domain. The average rating for statements measuring acceptability was 5.03. The average rating for statements that measured effectiveness was 5.05 and the average rating for statements that measured time efficiency was 4.95. These ratings indicate that all three teachers found the time-delay taped-words iPad intervention app to be acceptable, effective, and time efficient.

Do students find this intervention acceptable, effective, and time-efficient? All six participants completed questionnaires to rate the acceptability of this intervention using the Intervention Acceptability – Student Rating Form, a shortened and modified version of the BIRS (Elliott & Von Brock Treuting, 1991) created by the researcher. Ten statements were used to assess acceptability (*n*=5), effectiveness (*n*=3), and time (*n*=2) on a 6-point Likert-type scale with qualitative statements of "I do not agree" and "I agree" provided at either end of the scale.

The average rating for each statement is reported in Table 4. Ratings were also averaged based on qualitative domain. The average rating for statements measuring acceptability was 4.48. The average rating for statements that measured effectiveness was 5.13 and the average rating for statements that measured time efficiency was 5.25. Overall, these ratings indicate that students found the time-

Table 3.

Intervention Acceptability – Teacher Rating Form

Acceptability Statement	Mean Rating
1. This intervention appropriately targeted the student's academic weakness.	5.3
2. Most teachers would find this intervention appropriate to address sight word reading difficulties.	5.2
3. The student's reading difficulties were severe enough to warrant the use of this intervention.	4.5
4. This intervention produced lasting improvements to the student's sight word reading.	5.2
5. My student enjoyed the process of the intervention.	4.8
6. My student felt successful as a result of the intervention.	5.2
7. I would suggest the use of this intervention to other teachers.	5.0
8. This intervention would be appropriate for a variety of children.	5.2
9. This intervention would be easy to implement within my classroom.	5.0
10. By using this intervention in my classroom, I could address the needs of more students with little to no additional preparation time.	5.2
11. Access to this app would provide me with a valuable and reliable intervention tool, unlike other interventions that I have implemented in the past.	4.7
12. Overall, I liked the components of this intervention.	5.0

Table 4.

Intervention Acceptability – Student Rating Form

Acceptability Statement	Mean Rating
1. I liked using this app.	4.7
2. My friends would like to try this app.	4.5
3. This app helped me learn my sight words.	5.2
4. This app would help other students learn their sight words.	5.7
5. I am a better at reading because I used the iPad app.	4.5
6. I would like to keep using the iPad to practice my sight words.	3.8
7. The iPad was easy to use.	4.6
8. The iPad was fun to use.	4.8
9. The iPad was a fast way to practice my sight words.	4.7
10. I learned the words quickly.	5.8

delay taped-words iPad intervention app to be mostly acceptable, effective, and time-efficient.

The statement "I learned the words quickly" received the highest average rating (m = 5.8), which indicates that students found this intervention to be helpful in teaching them new words quickly. It is interesting to note that previous researchers have hypothesized this to be an important acceptability factor (Nist & Joseph, 2008; Pikulski & Chard, 2005). Students also agreed to statements, "this app would help other students learn their sight words" and "this app helped me learn

my sight words" which point to the perceived acceptability and effectiveness of this app.

Interestingly, the statement "I would like to keep using the iPad to practice my sight words" received the lowest average rating (*m* = 3.8). Individual responses for this statement ranged from quantitative ratings as low as 2 to as high as 6. The reason for this range in ratings is unknown, however, there are few possible hypotheses. For research purposes, students completed their intervention sessions individually in the researcher's office. Most students at this school receive their reading instruction within their classroom and/or in small groups in or near their classroom. Very few receive reading intervention individually or in a separate classroom. Thus, students' willingness to continue may be greater if the intervention were available within their classroom. Additionally, intervention sessions were conducted outside of the core instruction schedule. Therefore, students did not complete this intervention while they would have otherwise been in a reading group, but while the class was doing other activities such as doing morning work, partner activities, social studies instruction, or researching for a writing project. These activities are likely inherently rewarding and reinforcing to students and may be even more rewarding for students who struggle with reading. Therefore, it is hypothesized that the students who gave lower ratings (e.g., 2 or 3) may have disliked working individually or noted that they often completed the intervention during preferred activities. These are important considerations for future use of this intervention within the classroom or replicated research. This intervention is versatile and could be completed within the classroom as a reading center with one

or more iPads and headphones. Thus, these factors would be important considerations for future replications of this intervention.

Procedural Integrity

The main purpose of procedural integrity data in this study was to analyze the participants' ability to implement the intervention independently with fidelity. The researcher taught the participants how to use the iPad app and the expectations for the intervention. After doing so, the researcher allowed the participants to complete the intervention independently unless procedural prompts were necessary. The researcher videotaped one third of all sessions, and a research assistant viewed and coded each video for integrity using the Reliability Checklist (Appendix H). Results are reported as overall percent of procedures completed accurately.

Each participant was given a participant number and a code word. On average, participants were 89% accurate in selecting the correct participant number and 95% accurate at verifying their code word. When used in a classroom setting, these numbers and codes could simply be replaced with the students' names, which would further decrease the need for teacher assistance.

Participants were taught to use the iPad independently, which included starting the intervention and completing three intervention sessions per day. Participants accurately started the time-delay taped-words intervention app 95% of the time. On all occasions (100%), participants completed the requested number of sessions per day.

It was assumed that the participants' retention of the words and attention to task would increase if they were asked to read the words aloud. Therefore, participants were taught to "hear the word, say the word, find the word" while using the iPad app. Participants stated the words aloud on 95% of trials. Verbal or visual prompts that were necessary to complete the intervention with fidelity were also counted and averaged across participants. For example, a verbal prompt would include the researcher reminding the participant to read the words aloud. A visual prompt may have included showing the participant which button to touch to start the intervention. Participants completed the intervention without any prompts on 61% of occasions. The number of prompts was averaged across all coded sessions. On average, 1.05 prompts were required per session.

These data suggest that students can successfully implement the time-delay taped-words intervention app independently and with fidelity. This has significant implications for classroom use. First, the time-delay taped-words intervention has been supported in the research as an effective intervention for increasing sight word reading (e.g., Casey, 2008; Freeman & McLaughlin, 1984; Pummel, 2011). Secondly, access to an effective intervention that can be implemented by students independently allows teachers the ability to deliver core reading instruction to all students with access to intervention materials with no additional prep time. The intervention app keeps track of where the student left off the day before, which decreases the need for a teacher to help the student get started. Additionally, the teacher could use the intervention app as a reading center for students to practice

their sight words and receive immediate and corrective feedback while the teacher is working with other students.

DISCUSSION

This study empirically evaluated the effectiveness of using an iPad app to deliver a time-delay taped-words intervention. The empirical evaluation of this app aimed to add to the extensive base of research-validated literature that describes the effectiveness of the time-delay taped-words intervention (e.g., Casey, 2008; Freeman & McLaughlin, 1984; McCallum, Skinner, & Hutchins, 2004; Todd, 2010) and adds to the small yet growing literature base that focuses on using mobile technology to improve student learning (e.g., Mills, 2011; Pummel, 2011; Todd, 2010).

This app was constructed after implications from previous research suggested a mode of delivery that could be readily available and inexpensive for educators (Pummel, 2011). The format was designed to address concerns related to accurate reporting by students, which has been noted as a concern in previous computer and mobile device intervention applications intended to be implemented independently by students (e.g., Gibson et al., 2014; Pummel, 2011). The current intervention allowed for data to be collected and reported by the iPad. This eliminated the need for worksheets and external organizational strategies needed to collect and store data in previous replications of this intervention (Mills, 2011; Pummel, 2011; Todd, 2010).

The current study targeted students who were in need of academic support

at the Tier 2 and Tier 3 levels of a response to intervention (RTI) model. Response to intervention is a proactive approach of identification and service delivery designed to target students with behavioral or academic difficulties as soon as they begin to struggle (Justice, 2006; Rathvon, 2008). Participants were recruited during the 2014-15 school year from an elementary school in Montana. Participants included six second-grade students referred by their teachers as needing extra support in reading. These students were found to be at risk for reading difficulties according to teacher report, benchmark assessments, and reading inventories.

Major Findings

There were four major findings from this research study. First, all six participants demonstrated gains in reading Instant Words as measured by an inventory of the fifth 100 Instant Words (words 400-499) read pre- and post-intervention (Fry et al., 2000). These gains were maintained 2 weeks postintervention. Second, gains in Instant Word recognition generalized to overall gains in reading fluency, as measured by DORF (Good & Kaminski, 2002; Good, Kaminski, & Dill, 2007). Third, treatment integrity data showed that participants were able to complete the intervention procedures independently with a high degree of fidelity. Lastly, survey data from teachers and participants found that both view this intervention as effective, acceptable, and time-efficient.

Instant Word Reading

All participants demonstrated gains in reading the fifth 100 Instant Words (words 400-499) (Fry et al., 2000) after using the iPad app. Before using the iPad to practice and learn these words, participants were asked to read this list of 100 words to the researcher. If the participant didn't know a word, they were encouraged to give it a try and then told to move onto the next word. This same procedure was repeated after using the iPad to practice and learn these words. Prior to using the iPad app, participants read an average of 74.2% of the words. After using the time-delay taped-words iPad app participants could read 91.8% of the words. Therefore, an average gain of 17.6% words read correctly was observed. This assessment demonstrates the direct effectiveness of the iPad app to teach unknown words to students. In addition, this intervention was highly efficient, taking less than 3 minutes to complete a trial of 10 target words. Therefore, these increases in reading Instant Words were observed after less than 30 minutes of instruction, implemented in just over 3 days. The rapidity of these observed effects lends support to the internal validity of this intervention. The effectiveness was further demonstrated through the use of progress-monitoring probes to assess generalization.

Gains Maintained At Follow-Up

Major findings in this study included increases in reading Instant Words and generalization to oral reading fluency. These gains were maintained at follow-up for

all participants. For example, at 2 weeks postintervention, participants could read an average of 94% of the fifth 100 Instant Words (words 400-499), which is comparative to the average of 91.8% postintervention. In addition, participants also maintained the gains observed in oral reading fluency. The average number of WCPM at 2 weeks post intervention was 21.6 WCPM higher than at baseline, which was similar to the gain of 22.5 WCPM after intervention. These data indicated that the use of an iPad app to administer a time-delay taped-words intervention can produce lasting effects on students' word reading accuracy and oral reading fluency.

Generalization

Generalization was assessed using DORF (Good & Kaminski, 2002; Good, Kaminski, & Dill, 2007) probes. Reading fluency measures such as DORF are effective at assessing the efficacy of the interventions designed to promote reading (Schilling et al., 2007). Each participant completed three DORF probes before the intervention, after the intervention, and 2 weeks postintervention. The median words correct per minute (WCPM) are reported for each participant per assessment phase. Data indicated that intervention gains in word reading and recognition generalized to gains on DORF probes as seen by an average increase of 22.5 WCPM across participants from baseline to intervention.

Although possible confounding variables need to be considered, such as possible previous or concurrent reading instruction, this finding suggests that participants generalized the reading and recognition skills learned to novel words

and used their knowledge of learned Instant Words in order to more quickly and accurately read passages of connected text. This finding is unique because participants were not trained to read words in context and connect them together to fluently read a passage. Instead, the iPad app used a matrix-type layout that encouraged the discrimination and recognition of words.

Furthermore, the app provided additional practice reading known words (as demonstrated by scores on the first 300 Instant Words, Table 1.) with the added component of the time-delay. It is hypothesized that when participants practiced reading these words using the iPad app, they were encouraged to read them faster in order to "beat the iPad". Furthermore, as Fry (1980) reports, the first 300 words make up 65% of all written material. Therefore, the additional practice reading these words quickly may partly explain the increase in WCPM.

Another built-in component of the iPad app was immediate and corrective feedback. In addition to providing participants feedback regarding incorrectly recognized words, this component likely reinforced correct discrimination between visually similar words (e.g., these/there, who/how, etc.) and may have contributed to the overall increase in WCPM.

Still further, the use of the iPad app may have contributed to gains in students' self-efficacy related to reading ability and academic competency. This intervention provided students with corrective feedback without possible negative implications for incorrect performance. Thus, as they progressed through each time-delay trial and were able to recognize words more quickly, they likely became more

confident in their ability to read and recognize words. This confidence may have contributed to gains in WCPM in reading connected text.

Procedural Integrity

The iPad app was designed with the intention of providing teachers with a research-based intervention that students could utilize independently. Access to interventions that supplement instruction, create academic gains, and preserve teacher preparation time could prove important to the educational success of students and support the effectiveness of teachers' instruction. Procedural integrity focused on students' ability to implement the intervention independently and with reliability. Data showed that, on average, participants needed about one prompt per intervention session. However, over 60% of intervention sessions were completed without any prompts provided by the researcher. Therefore, these data suggest that students can implement this intervention independently and with fidelity. Small changes can occur within a classroom to increase independence. For example, replacing participant numbers with student names could reduce confusion. Also, using the iPad app as a reading station with three or four iPads would also allow a student to ask other students for procedural help rather than requiring teacher assistance. Overall, participants were able to implement the intervention with a high degree of independence.

Treatment Acceptability

Teachers evaluated the iPad intervention app by rating statements across a 6-point Likert-type scale. Statements were intended to measure components of acceptability, effectiveness, and time. The average rating for statements measuring acceptability, effectiveness, and time were 5.03, 5.05, and 4.95, respectively. The qualitative variable attached to a rating of 5 was "agree." Therefore, overall, teachers agreed that the time-delay taped-words intervention using an iPad app was acceptable, effective at addressing their students' academic need, and time-efficient.

Students also rated the iPad intervention app by rating statements across a 6-point Likert-type scale. The average rating for statements measuring acceptability, effectiveness, and time were 4.48, 5.13, and 5.25, respectively. These ratings indicated that the participants found this intervention to be acceptable across all domains.

Additionally, results from baseline measures as reported in Table 1 suggested that on average, baseline lists consisted of 90% known to 10% unknown word. Burns and Dean (2005) explored the optimal instructional level for drill tasks by comparing four different drill ratios (0% known, 50% known, 83% known, and 90% known) and the effect on retention and on-task behavior. Participants in their study included 5 fourth-grade students with reading disabilities and documented attention difficulties. Results suggested that the instructional ratio of 90% known to 10% unknown led to the highest retention and percentage of on-task behavior. While examining on-task behavior was outside of the scope of the current study, the

impact of drill ratios is interesting to consider. Average percent correct on baseline measures indicated that participants accurately recognized 95.3% of words. Average percent on maintenance measures stayed relatively consistent at 94.7%. However, when considering reading performance on the fifth 100 Instant Words (words 400-499), participants accurately read an average of 74.2% of words before completing the intervention phase. This ratio of known to unknown words falls within the instructional level of 70-85% proposed by Gickling & Thompson (1985) (as cited in Burns & Dean, 2005). At maintenance, 94% of these words were retained. These results indicate that both ratios produced similar retention results. Additionally, it is important to note that these research studies (Burns & Dean, 2005) created individual lists for their participants based on words known and unknown by each individual. The current iPad intervention app did not select words individually for students, but rather utilized the Instant Words (Appendix E) (Fry et al., 2000) so that students would progress through the intervention encountering the most frequent words of decreasing frequency. Therefore, it was expected that most lists would be comprised of known and unknown words, but the ratio was not predetermined. Research techniques such as the folding-in procedures used in past research are more laborious, as they require pretesting and more preparation time and materials to create individual interventions packets for each student. The current intervention appeared to inherently provide similar ratios of known to unknown words as suggested by previous research without creating individualized intervention materials for each student. Future research could further explore drill

ratios on intervention effects using the time-delay taped-words intervention to either confirm or disprove this hypothesis.

Limitations

Limitations of the current study included the difficulty of words chosen as dependent variables. The dependent variable was the percent of words recognized correctly on the 2-second time-delay during baseline, intervention and maintenance phases. The baseline phase included 90 words randomly chosen from the first 300 Instant Words (Fry et al., 2000). Thirty words were chosen from the first 100 (words 1-99), 30 from the second 100 (words 100-199), and 30 from the third 100 (words 200-299). Since the frequency of these words decreased across each group of 100 words, a decreasing or stable baseline trend was expected. In addition, it was expected that the students referred for this intervention would not have demonstrated mastery (>80%) of these words at baseline. These expectations drove the design of this research study and development of the iPad app. It was anticipated that this design would bridge research and practice by allowing teachers to see the immediate gains of their students as they progressed through practicing words, starting with the most frequent and progressing into the next group of 100 words. However, as was observed by scores on baseline measures (Table 1), participants had already achieved mastery of these words, and therefore growth was difficult to demonstrate and results did not show increases in Instant Word recognition, as was hypothesized. Future research replicating the effectiveness of

this intervention should consider using baseline measures adjusted to the student's level of mastery, administering the intervention to younger students, or replicating using an alternate design, such as a multiple-baseline design, to better demonstrate internal validity.

Threats to internal validity arise when alternative interpretations of the variable responsible for change, other than the treatment, exist (Kazdin, 1981). Internal validity of the iPad intervention app was not established through manipulation of the dependent variable. Therefore, it is impossible to conclude that generalization effects are strictly attributable to the use of the iPad intervention app. It is possible that other factors in the students' instruction contributed to the observed increases. However, it is interesting to note that generalization scores remained relatively stable for five of the six participants after the removal of the intervention. Only one student (Participant 6) demonstrated an increase in his DORF score from intervention to maintenance. This pattern provides evidence for a causal relationship between the iPad intervention app and increases in oral reading fluency, but does not rule out other possible contributing factors.

The current study was implemented under research conditions, outside of the typical classroom environment. Although the researcher is also the school psychologist, implementing an academic intervention is outside of the typical role in this particular school. A separate setting was also necessary for the integrity of the research and confidentiality of the participants. Nonetheless, results may vary if implemented in the classroom as part of the typical routine. Gibson et al. (2014)

noted that findings are even more convincing when interventions are carried out by school staff under typical conditions.

Implications for Future Research

Further research and development of this intervention could capitalize on the efficiency of the intervention in other academic areas, grades, or tiers of instruction. For example, a similarly programmed app could easily be used to teach letter sounds, math facts, or vocabulary words. The current app contains 1,000 Instant Fry words (Fry et al., 2000). Therefore, it could be used with students through the elementary grades, into middle school, or with high school students with significant learning disabilities. A similar time-delay taped-problems app could be used to teach vocabulary throughout the grades, and even programmed to teach subject-specific vocabulary (e.g., biology). Applications using the time-delay taped-problems strategy can be made for a variety of needs from remediation to core instruction to enrichment. Additionally, future research could explore the use of this app as an individual intervention or group intervention. For example, would an app programmed for two students to compete against each other produce greater results than students practicing these words individually?

Another component unique to the implementation of this intervention by the iPad app is the presentation of words using a matrix-type layout. This format utilizes constructs of recognition and discrimination between the target word and other high-frequency words, whereas previous time-delay taped-words research

studies used lists of words for the presentation and audiotapes for feedback. In this study, each target word was presented in the matrix-type layout with three other high-frequency words as distractors (Figure 1). Each target word was presented at each of three time-delays. Therefore, the participant learned to discriminate each target word from nine other high-frequency words. Additionally, each target word was also paired as a distractor word against other target words. Therefore, participants were not only taught to recognize the target word, but to discriminate between it and other high-frequency words. Future research could explore the implications and effectiveness of recognition and discrimination in programming future applications. Additionally, this application paired target and distractor words based on frequency in written text. Other applications may consider pairing words based on traits such as beginning letters, word families, or suffixes and prefixes.

Lastly, another consideration that was beyond the scope of this study explores components of apps that either enhance or distract from learning. For example, many mainstream game and educational applications include significant amounts of visual and auditory stimuli (e.g., lights and sounds) coupled with goals and levels that make the application appear as a game. The current iPad app used a minimalistic design that included black and white fonts paired with red and green to indicate correct and incorrect. Goals were reported using green and red dots to indicate mastery or failure to achieve mastery. The only auditory stimulus was provided in the form of corrective feedback. Thus, the current application was simpler than most currently available for purchase. Future research could explore

the impact of external stimuli on a student's desire to learn, expended effort to master material, and amount of growth made. One could hypothesize that as our youth become accustomed to being entertained by mobile technology, they may become less interested in using it to learn. Conversely, not enough stimuli and interactive play could discourage interest and therefore reduce effects. Thus, research is needed to determine an appropriate level of stimuli that promotes captivation but does not discourage the internal motivation to learn.

APPENDIX A

LETTER TO PARENTS

Dear Parent,

Your child's participation in a research study is requested. The research study is being conducted at your child's school by the school psychologist, Mary Beth Pummel. Mrs. Pummel is also a graduate student from the Department of Educational Psychology at the University of Utah. The research study is designed to improve your child's ability to read sight words accurately and quickly. Your child will practice lists of sight words using an iPad app that will allow your child to know whether he/she has read the words correctly.

Your consent to allow your child to participate in this study is completely voluntary. Choosing not to allow your child to participate or withdrawing consent will not affect his/her relationship with school personnel or the researcher. Up to **six students** will be chosen to take part in this study. Therefore, permission does not guarantee your child's participation in the study.

Please refer to the included Parental Permission Document for more information about the study. Please contact the researcher with any questions or concerns about the study. Should you choose to allow your child to participate in this study, please complete the form and return it to your child's teacher in a sealed envelope addressed with **Attn: Mary Beth Pummel**. Please return the permission form by _____. Should you choose not to allow your child to participate in the research study, please check the box in the Refusal to Consent section and return it to your child's teacher in a sealed envelope addressed with **Attn: Mary Beth Pummel** by _____.

Sincerely,

Mary Beth Pummel, M. S.

Graduate Student
Department of Educational Psychology
University of Utah
(406) 522-6706
marybeth.pummel@bsd7.org

APPENDIX B

PARENTAL PERMISSION DOCUMENT

Parental Permission Document

BACKGROUND

Your child is being asked to take part in a research study. Before you agree to participation, it is important for you to understand the rationale and details of the study. Please read the following information carefully. The purpose of the study is to assess the effectiveness of an iPad app to increase your child's ability to read sight words quickly and accurately.

STUDY PROCEDURE

The study will be approximately 10 to 12 weeks in length and will be conducted at your child's school. The intervention will take place 3 to 4 days per week and take approximately 10 minutes per day to complete. During the intervention, your child will use an iPad app. The app will show words that are frequently used in the English written language. The app will show four words at a time and state one word that it wants your child to find. Your child will try to "beat" the iPad by touching the correct word before the iPad gives the answer. If they choose the wrong word the iPad will tell them the right word. Your child will practice these words three times with three different time-delays. Each session contains 10 target words. Your child will complete three sessions per day. This will give him/her the opportunity to practice and learn up to 30 words each day.

Prior to beginning the study and at the conclusion of the study your child will complete measures that will assess his/her accuracy and speed of reading. These measures will be administered by the researcher and will take approximately 30 minutes to complete. These measures will help us to determine whether the use of the intervention contributed to an increase in your child's ability to read sight words quickly and accurately.

In order to assess the fidelity of the intervention, video recording will be utilized. The researcher will record every third intervention day to be analyzed by a research assistant. The purpose of this data is to assess information about the intervention, such as how much assistance the student needed to use the iPad and complete the sight words game.

At the end of the study, your child will be asked to complete a questionnaire that will allow us to understand how children perceived this intervention. He/she will be given statements such as "This app helped me learn my sight words" and asked to select a rating from a continuum of choices between "I do not agree" and "I agree". You have the right to preview this questionnaire before providing consent. If you would like to preview this questionnaire please contact the researcher by phone or email, listed below.

Your child's teacher will also be asked to complete a questionnaire that will allow us to understand how teachers perceived this intervention. They will be given statements such as, "This intervention produced lasting improvements to the student's sight word reading," and asked to select a rating to indicate the degree to which they agree or disagree with the statement. The statements are directed at the teacher's overall perception of the intervention on factors related to acceptability, effectiveness, and time.

Your permission will allow the researcher to access and report certain records pertaining to your child. This information will be included as interpretation in the methods, procedures, and results section of the researcher's dissertation and corresponding methods used to report the results of the intervention. These records may include previous reading fluency scores, the age of the student as reported in years and months, and your child's gender. Educational status such as grade retention, qualification and classification in Special Education, and/or previous inclusion in academic interventions may also be reported. Attendance will only be reported as it pertained to attendance in the research study. For example, whether the student missed a significant portion of the intervention due to absence from school. Personally identifiable information such as your child's name, date of birth, or teacher will NOT be reported. Instead, the information described above will be attached to a generic label such as Participant 1.

This research study and its results will be written in a dissertation as partial fulfillment of a Ph. D. requirement for the researcher. These results will be shared with students and faculty from the University of Utah and BSD7 personnel. This research study and its results may also be submitted for peer review, publication, and presentation.

RISKS

The potential risks for participating in this study are minimal. One foreseeable risk associated with this study is the missed classroom instruction/activity time. Participation in this study will require your child to miss approximately 10 minutes of regular classroom time each day. Although it is not anticipated, there is a risk of loss of confidentiality that could result from inadvertent disclosure of study related data.

BENEFITS

We cannot guarantee any direct benefit to your child for taking part in this study. However, there are potential benefits for participation. One benefit may include an increase in your child's ability to correctly identify sight words. Your child may also experience an increase in his/her ability to read quickly and accurately. In turn, this may also result in an increase in reading comprehension and overall achievement in reading.

CONFIDENTIALITY
Your child's information and data will be kept confidential. Data and records will be stored on the iPad and in a locked filing cabinet in the researcher's office. All information and data obtained will be used solely for research purposes. Only the researcher, members of her research team, and the BSD7 Deputy Superintendent of Instruction will have access to this information. If you would like your child's results shared with the school team you may indicate this on the consent page or supply the researcher with a written request authorizing the release of this information. In publications, your child's name will be replaced with a generic label such as "Participant 1".

PERSON TO CONTACT
Please contact the researcher, Mary Beth Pummel, with all questions, concerns, or complaints regarding this study. The researcher can be contacted via phone at (406) 522-6706 or via email at marybeth.pummel@bsd7.org. If you feel your child has been harmed as a result of participation in this research study, please contact Mary Beth Pummel who can be reached Monday through Friday 8 AM to 4 PM at the phone number or email listed above.

Institutional Review Board: Contact the Institutional Review Board (IRB) if you have questions regarding your child's rights as a research participant. Also, contact the IRB if you have questions, complaints or concerns which you do not feel you can discuss with the investigator. The University of Utah IRB may be reached by phone at (801) 581-3655 or by e-mail at irb@hsc.utah.edu.

Research Participant Advocate: You may also contact the Research Participant Advocate (RPA) by phone at (801) 581-3803 or by email at participant.advocate@hsc.utah.edu.

VOLUNTARY PARTICIPATION
Your consent to allow your child to participate in this study is voluntary. Refusal to participate or the decision to withdraw your child from the study at any time will not result in any penalty or loss of benefits to which your child is otherwise entitled. In addition, this will not affect your child's relationship with the researcher or school personnel.

COSTS AND COMPENSATION TO PARTICIPANTS
There is no cost to participate in this study. Participants will not be compensated for participation.

Please complete this form and return to your child's teacher in a sealed envelope addressed with Attn: Mary Beth Pummel.

CONSENT
By signing this consent form, I confirm I have read the information in this parental permission form and have had the opportunity to ask questions. I will be given a

signed copy of this parental permission form. I voluntarily agree to allow my child to take part in this study.

_____
Child's Name

_____
Parent/Guardian's Name (print)

_____ _____
Parent/Guardian's Signature Date

_____
Relationship to Child

_____
Name of Researcher or Staff

_____ _____
Signature of Researcher or Staff Date

Optional

□ I would like the results of my student's study data shared with the school team.

_____ _____
Parent/Guardian's Signature Date

REFUSAL TO CONSENT

□ I have read the information in the parental permission form and have decided to NOT allow my child to participate in the research study.

_____
Child's Name

_____
Parent/Guardian's Name

APPENDIX C

ASSENT TO PARTICIPATE

Assent to Participate in a Research Study

Who are we and what are we doing?
We are from the University of Utah. We would like to ask if you take part in a research study. A research study is a way to find out new information about something. We are studying how to use apps to help kids learn to read!

Why are we asking you to be in this research study?
We are asking you to be in this research study because we want to learn more about how to help kids like you read more quickly.

What happens in the research study?
If you decide to be in this research study and your parents agree, the researcher will meet with you 4 days a week for 4 weeks. Each time will be about 10 minutes. The entire study will be about 10 to 12 weeks long. You will be taught how to use a game on the iPad. To win the game you need to find a word as quickly as you can. This game will help you learn to read words more quickly.

At the end of the study, you will be asked to complete a survey. It will ask you if you liked the study. It will also ask if you if the iPad helped you read better.

Will any part of the research study hurt you?
If you choose to take part in this study, you will miss some class time. It will be about 10 minutes each day. Other children may notice you leaving and ask you why.

Will the research study help you or anyone else?
We do not know for sure if this research study will help you. It is possible that you may be able to read more quickly. It is also possible that we could learn more about how to help other kids read more quickly too.

Who will see the information about you?
All of your records for the study will be kept locked up. No one but the experimenter can see them. Instead of using your name you will be given a number. Only you and the experimenter will know which number is yours.

What if you have any questions about the research study?
It is okay to ask questions. If you don't understand something, you can ask us. We want you to ask questions now and anytime you think of them. If you have a question later that you didn't think of now, you can call Mary Beth Pummel or ask the next time I see you. My number is (406) 522-6706.

Do you have to be in the research study?
If you don't want to be in this study, you don't have to. Being in this study is up to you. No one will be upset if you don't want to participate. You can change your mind later if you want to stop. Please talk about this with your parents. We will also ask your parents to give their permission too. But even if your parents say "yes" you can still say "no".

Agreeing to be in the study
I was able to ask questions about this study. Signing my name at the bottom means that I agree to be in this study. My parents and I will be given a copy of this form after I have signed it.

_____
Printed Name

_____ _____
Sign your name on this line Date

_____
Printed Name of Person Obtaining Assent

_____ _____
Signature of Person Obtaining Assent Date

The following should be completed by the study member conducting the assent process if the participant agrees to be in the study.

Initial the appropriate selection:

_____ The participant is capable of reading the assent form and has signed above as documentation of assent to take part in this study.

_____ The participant is not capable of reading the assent form, but the information was verbally explained to him/her. The participant signed above as documentation of assent to take part in this study.

APPENDIX D

CONSENT COVER LETTER

Consent Cover Letter

THE USE OF AN IPAD APP TO DELIVER A TIME-DELAY TAPED-WORDS

INTERVENTION TO STUDENTS AT RISK FOR READING DIFFICULTIES

The purpose of this research study is to empirically evaluate the effectiveness of using an iPad app to deliver time-delay taped-words intervention to increase the sight word accuracy of second and third grade students in the general education setting who are at risk for reading deficits. We are doing this study to investigate the effectiveness and acceptability of using high interest technology to deliver academic interventions.

I would like to ask for your participation in this research study. Participation in this study will include permission to allow your students out of class to complete the intervention sessions. The estimated time out of class per student is 10 minutes per day, 4 days per week for approximately 10 to 12 weeks. Although the actual intervention will run for just 4 weeks, the completion of pre- and post-intervention measures will add additional length onto the time required for the study.

Participation in this study will also require that you complete two questionnaires. The first questionnaire will need to be completed prior to your student beginning the intervention and will serve as a screening measure for emotional and behavioral problems. The completion of the second questionnaire will be requested after the intervention sessions have been completed. The data collected from the questionnaire will be viewed by the primary investigator, research assistant, and faculty sponsor. The questionnaire will not ask that you disclose any identifying information such as your name. The data collected will be reported anonymously in publications as collected from the teacher.

The risks for participation in this study are minimal. Some foreseeable risks are the loss of class or instructional time for students and the time needed to complete the questionnaires. Results from the first questionnaire will be used as exclusionary criteria. These results may be reported with a phrase that begins with “the teacher of Participant 1” and thus will not contain personally identifiable information. The second questionnaire will not ask for identifiable information such as your name, and therefore the risk of loss of confidentiality is not a concern.

We cannot guarantee any benefit for participation in this study. However, potential benefits may include an increase in the student’s ability to correctly identify sight words and the exposure to an academic intervention that can be administered independently and effectively by students.

If you have any questions, concerns, or complaints or if you feel you have been harmed by this research please contact Mary Beth Pummel, Department of Educational Psychology, University of Utah at (406) 522-6706 or by email at marybeth.pummel@bsd7.org.

Contact the Institutional Review Board (IRB) if you have questions regarding your rights as a research participant. Also, contact the IRB if you have questions, complaints, or concerns which you do not feel you can discuss with the investigator. The University of Utah IRB may be reached by phone at (801) 581-3655 or by e-mail at irb@hsc.utah.edu.

It should take approximately 5 to 20 minutes to complete each questionnaire. Participation in this study is voluntary. You can choose not to take part and you can also choose not to finish the questionnaire or omit any question you prefer not to answer without penalty or loss of benefits.

By returning this questionnaire, you are giving your consent to participate. Thank you for your participation.

APPENDIX F

INSTANT WORDS

Instant Words (Fry, et al., 2000)			
The first hundred			
(1-99)			
the	or	will	number
of	one	up	no
and	had	other	way
a	by	about	could
to	words	out	people
in	but	many	my
is	not	then	than
you	what	them	first
that	all	these	water
it	were	so	been
he	we	some	called
was	when	her	who
for	your	would	oil
on	can	make	sit
are	said	like	now
as	there	him	find
with	use	into	long
his	an	time	down
they	each	has	day
I	which	look	did
at	she	two	get
be	do	more	come
this	how	write	made
have	their	go	may
from	if	see	part
The second hundred			
(100-199)			
over	say	set	try
new	great	put	kind
sound	where	end	hand
take	help	does	picture
only	through	another	again
little	much	well	change
work	before	large	off
know	line	must	play
place	right	big	spell
years	too	even	air
live	means	such	away
me	old	because	animal
back	any	turn	house

give	same	here	point
most	tell	why	page
very	boy	ask	letter
after	follow	went	mother
things	came	men	answer
our	want	read	found
just	show	need	study
name	also	land	still
good	around	different	learn
sentence	form	home	should
man	three	us	America
think	small	move	world
The third hundred			
(200-299)			
high	saw	important	miss
every	left	until	idea
near	don't	children	enough
add	few	side	eat
food	while	feet	face
between	along	car	watch
own	might	mile	far
below	close	night	Indian
country	something	walk	real
plant	seem	white	almost
last	next	sea	let
school	hard	began	above
father	open	grow	girl
keep	example	took	sometimes
tree	begin	river	mountains
never	life	four	cut
start	always	carry	young
city	those	state	talk
earth	both	once	soon
eyes	paper	book	list
light	together	hear	song
thought	got	stop	being
head	group	without	leave
under	often	second	family
story	run	late	it's
The fourth hundred			
(300-399)			
body	order	listen	farm
music	red	wind	pulled

color	door	rock	draw
stand	sure	space	voice
sun	become	covered	seen
question	top	fast	cold
fish	ship	several	cried
area	across	hold	plan
mark	today	himself	notice
dog	during	toward	south
horse	short	five	sing
birds	better	step	war
problem	best	morning	ground
complete	however	passed	fall
room	low	vowel	king
knew	hours	true	town
since	black	hundred	I'll
ever	products	against	unit
piece	happened	pattern	figure
told	whole	numeral	certain
usually	measure	table	field
didn't	remember	north	travel
friends	early	slowly	wood
easy	waves	money	fire
heard	reached	map	upon
The fifth hundred			
(400-499)			
done	decided	plane	filled
English	contain	system	heat
road	course	behind	full
half	surface	ran	hot
ten	produce	round	check
fly	building	boat	object
gave	ocean	game	am
box	class	force	rule
finally	note	brought	among
wait	nothing	understand	noun
correct	rest	warm	power
oh	carefully	common	cannot
quickly	scientists	bring	able
person	inside	explain	six
became	wheels	dry	size
shown	stay	though	dark
minutes	green	language	ball
strong	known	shape	material
verb	island	deep	special
stars	week	thousands	heavy

front	less	yes	fine
feel	machine	clear	pair
fact	base	equation	circle
inches	ago	yet	include
street	stood	government	built

APPENDIX F

TEACHER INTERVENTION ACCEPTABILITY

Intervention Acceptability – Teacher Rating Form

	Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree
1. This intervention appropriately targeted the student's academic weakness.	1	2	3	4	5	6
2. Most teachers would find this intervention appropriate to address sight word reading difficulties.	1	2	3	4	5	6
3. The student's reading difficulties were severe enough to warrant the use of this intervention.	1	2	3	4	5	6
4. This intervention produced lasting improvements to the student's sight word reading.	1	2	3	4	5	6
5. My student enjoyed the process of the intervention.	1	2	3	4	5	6
6. My student felt successful as a result of the intervention.	1	2	3	4	5	6
7. I would suggest the use of this intervention to other teachers.	1	2	3	4	5	6
8. This intervention would be appropriate for a variety of children.	1	2	3	4	5	6
9. This intervention would be easy to implement within my classroom.	1	2	3	4	5	6
10. By using this intervention in my classroom, I could address the needs of more students with little to no additional preparation time.	1	2	3	4	5	6
11. Access to this app provided me with a valuable and reliable intervention tool, unlike other interventions that I have implemented in the past.	1	2	3	4	5	6
12. Overall, I liked the components of this intervention.	1	2	3	4	5	6

APPENDIX G

STUDENT INTERVENTION ACCEPTABILITY

Intervention Acceptability – Student Rating Form

	I do not agree I agree
1. I liked using this app.	|--------|--------|--------|--------|--------|
2. My friends would like to try this app.	|--------|--------|--------|--------|--------|
3. This app helped me learn my sight words.	|--------|--------|--------|--------|--------|
4. This app would help other students learn their sight words.	|--------|--------|--------|--------|--------|
5. I am a better at reading because of the iPad app.	|--------|--------|--------|--------|--------|
6. I would like to keep using the iPad to practice my sight words.	|--------|--------|--------|--------|--------|
7. The iPad was easy to use.	|--------|--------|--------|--------|--------|
8. The iPad was fun to use.	|--------|--------|--------|--------|--------|
9. The iPad was a fast way to practice my sight words.	|--------|--------|--------|--------|--------|
10. I learned the words quickly.	|--------|--------|--------|--------|--------|

APPENDIX H

RELIABILITY CHECKLIST

Participant # 1□ 2□ 3□ 4□ 5□ 6□

Phase observed: Baseline□ Intervention□ Maintenance□

Video number: _____

1. Participant chose the correct participant number. Yes☐ No☐
    a. Researcher had to verify participant number. Yes☐ No☐
2. Researcher asked if the code word was correct and the participant responded Yes□ No□
3. Participant chose the "play" button and proceeded to complete the sessions. Yes☐ No☐
4. Verbal or visual prompts (corrections to an intervention procedure) were required by the researcher. Yes☐ No☐ 0□ 1□ 2□ 3□ 4□ 5□ 6□
5. The participant read the words aloud as after the iPad. Yes☐ No☐
6. The participant completed the appropriate number (3) of intervention sessions for the day? Yes☐ No☐

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